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CEEFAX: field trials at v.h.f. using System B-Bavaria-April 1975

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Summary

Tests have been conducted to assess the suitability of the Teletext unified-standard parameters for use with the v.h.f. System B television standard.

This work was undertaken jointly by the BBC and IBA with the co-operation of the IRT. Apparatus was also made available for the tests by members of BREMA and by a German manufacturer of professional equipment.

Field tests were conducted in Bavaria from the 16th to the 24th April, 1975, within the service area of the Wendelstein System B transmitter. In addition, information was provided by the IRT about the performances of various television networks, transmitters and transposers used in Germany.

Overall, the tests have shown that the Teletext parameters as specified in the unified-standard specification are suitable for use with the v.h.f. television System B standard of transmissions.

Issued under the authority of

G.D. Monteath

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1. Introduction

The unified standard parameters for Teletext as proposed in the current specification,[1] are intended to be suitable for a v.h.f. television transmission system. Following the eventual closure of the 405-line monochrome system in the U.K., it is possible that the frequency bands they occupy might be made available for 625-line colour services. Further, in the event of other European Countries considering the provision of a Teletext Service, it would aid standardisation if the U.K. system had been shown suitable for use with European v.h.f. transmission systems.

Field trials aimed at determining the CEEFAX service area, which have been conducted in the U.K. with u.h.f. System I transmissions from the Crystal Palace transmitter,[2] show a substantial margin between the television and CEEFAX service areas in favour of CEEFAX. It might be expected that a v.h.f. service would suffer more than a u.h.f. service from interference due to multipath distortion and impulsive noise, in view of the inferior directive characteristics of v.h.f. domestic television aerials. Moreover, the lower field strength in the v.h.f. 'fringe area' might increase the susceptibility of such transmissions to man-made interference.

During 1974 the Institut für Rundfunktechnik (IRT) in Munich was approached with a view to making joint tests, in Germany, broadly similar to those carried out in the U.K. The IRT agreed to co-operate in the field trials and suggested that a System B transmitter in Bavaria would be suitable for the tests.

The tests would provide the opportunity to assess any fundamental difficulties due to the System B television standard, in particular the lower nominal video-bandwidth and narrower vestigial sideband, and to enable v.h.f. propagation studies to be made. The main differences between System B and System I are shown in Tables 1 and 2; their characteristics are given in full elsewhere.[3]

Brief preparatory tests were made in Bavaria in December, 1974. Three sites were visited and transmissions originating from BBC and IBA data sources were measured. These earlier tests were of considerable assistance in planning the main trials; some of the findings are included in this Report.

The main field work took place between the 16th and 24th of April, 1975. In the period November, 1974 to April, 1975 preparations were made, involving full equipment checks.

2. Organisation of the tests

2.1. General

In order to make a complete assessment of the performance of Teletext when transmitted with television System B, it would have been necessary to conduct very extensive surveys. It would also have been necessary to study the performances of a wide range of network paths and transmitters and to carry out tests in a number of different service areas, using a wide range of receiving apparatus. Such a programme of work would have been lengthy and demanding in effort.

In practice, only two weeks were available for the tests, during which Teletext could be radiated from one transmitter for only eight days. Hence, the scope of the tests that could be conducted was severely limited.

In order to derive maximum information from this work, each aspect of the tests was planned to occupy the minimum of time although, in some cases, this required more preparation and a more lengthy analysis of results. A number of tests were conducted, in advance, by the IRT to help assess the performances of network paths and transmitters.

TABLE 1

The Main Points of Difference Between the Specifications: 'System B' and 'System I'

	B	I
Nominal video bandwidth (MHz)	5·0	5·5
Nominal radio-frequency channel bandwidth (MHz)	7·0	8·0
Frequency of sound carrier relative to vision carrier (MHz)	+5·5	+6·0
Nominal width of vestigial sideband (MHz)	0·75	1·25
Peak white level as a percentage of peak carrier	10—12·5	20
Ratio of e.r.p.'s, peak vision : sound	20:1	5:1
Group delay pre-correction	Table 2	None

TABLE 2

Group-Delay Pre-Correction Characteristic for System B

Frequency (MHz)	Delay (ns)
0·25	+5±0
1·00	+53±40
2·00	+90±40
3·00	+75±40
3·75	0±40
4·43	−170±40
4·80	−400±90

(PH-171)

The Wendelstein Band III transmitter was chosen for the tests; it serves Munich, where the IRT Research Laboratories are situated, and the local terrain provides a wide range of different propagation conditions. By studying the performance using this transmitter and by observing the various effects of propagation conditions it was considered that a fairly general result could be deduced from a relatively small number of site measurements.

2.2. Criteria for choice of sites

The test sites were selected to give as representative a survey as possible of coverage within the service area of the Wendelstein transmitter. As they were chosen to assess the effects, on Teletext reception, of different propagation conditions and forms of interference, and to isolate the effects caused by the transmitter, the sites were selected:

(a) according to the distribution of population within the service area,

(b) to give a variety of reception conditions,

(c) to include at least two 'clean' sites (i.e. virtually free from multipath effects and other interferences).

In some cases excursions were made outside the normal service area and to sites with little or no population, in order to gain a wide range of reception conditions. In addition, some tests were conducted using commercial aerial distribution systems by taking a limited set of apparatus into the homes of some employees of the IRT.

A diagram showing the location of the sites visited relative to the service area is given later in the report.

2.3. Criteria used to assess Teletext reception

After studying the effects of the System B parameters and propagation effects at v.h.f., a criterion must be applied in order to estimate the proportion of television viewers able to receive a satisfactory Teletext service.

Teletext, being a digital system, does not suffer a progressive impairment with a reduction of signal quality and therefore is unlike a picture signal; added noise or distortion has no effect on the displayed Teletext signal until a threshold is reached. Beyond this point errors occur in the displayed text. Hence, even when the received picture quality is visibly impaired, the Teletext signal may be received and decoded error free. But in a marginal reception condition, errors might arise.

There is no simple relationship between the rate of occurrence of errors and the acceptability of the Teletext signal. The inherent flexibility of the system implies that one type of page (such as that carrying a subtitle) may be transmitted twice in immediate succession, whereas a 'sub-page' of a magazine transmitted sequentially with other magazines may be repeated only after several minutes. The error rate accepted as the 'edge of service' therefore depends to some extent on how the system is used by a broadcaster. In order to provide a firm basis for decisions, four definitions of a satisfactory service were adopted (Table 3). The extreme definitions (A) and (D) are easier to use in the field and 'bracket' the others. The intermediate definitions (B) and (C) could be taken as corresponding to failure of service in a typical service where the page repetition rate is long (B) or short (C).

2.4. Receiving apparatus

To assess the service that might be expected in practice, it would be necessary to use a wide range of

TABLE 3

Criteria Used to Assess Teletext

Criteria used	Maximum error probability (assessed in analysis of test results)	
	Character error probability	Equivalent bit error probability
A. No errors received in 10 seconds for entire data stream	$1{\cdot}2 \times 10^{-5}$	$1{\cdot}6 \times 10^{-6}$
B. No visible errors in each of 3 consecutive new acquisitions of one page	$1{\cdot}7 \times 10^{-4}$	$2{\cdot}2 \times 10^{-5}$
C. No visible errors remaining after the second writing of one page	$2{\cdot}3 \times 10^{-2}$	$2{\cdot}8 \times 10^{-3}$
D. About half of the characters correct for each new acquisition of one page	0·5	4×10^{-2}

domestic apparatus in the tests. Several domestic System B receivers and prototype decoders were provided by British manufacturers and could have been used for this purpose. However, such an approach would have had the following disadvantages.

(i) It would have been time-consuming to test each combination of apparatus at each site.

(ii) At a later date, it would have been difficult to assess the effects of any development or general improvement in the design of domestic apparatus.

(iii) Using solely domestic apparatus it would have proved difficult either to make a qualitative assessment of the received signal or to measure the performance of the transmitter from a 'clean site'.

Professional apparatus of good calibrated performance was used for many of the tests. Detailed measurements were made on the received television waveform and the received Teletext signal was applied to two laboratory Teletext decoders which incorporated special signal-quality monitoring facilities. A domestic receiver with prototype integral Teletext decoder was also used at most sites in order to ensure that the range of domestic apparatus available was always represented.

Using this combination of equipment, accurate measurements could be made and detailed results obtained such that, in theory, the performance obtained with any receiving apparatus could be predicted. Consequently a realistic specification could be set for domestic Teletext apparatus for System B, based on the results obtained with the professional and domestic apparatus.

2.5. Measuring the quality of the received signal

Measurement techniques were selected which gave the maximum of information about the signal and required a minimum of time during the field trials in Germany as discussed in 2.1. All waveform measurements were made by photographing the relevant section of the waveform together with any necessary calibration markers, so that a more detailed study of the waveforms could be made later.

A pulse and bar signal consisting of a positive 1T pulse, a bar and a negative 1T pulse within the bar were transmitted for the duration of the tests, as well as the normal ITS waveforms including the 2T pulse, 20T chrominance pulse etc. The magnitude of the 1T pulse and bar signal was adjusted so that the peak level of the bar was the same as the nominal Teletext data-signal level. The signal was used to enable a complete analysis of the linear distortions acting on the Teletext data waveform to be made, either at the output of a video or r.f. system when fed with signals from test generators and modulators, or at a site.

1T pulses were selected for this work because their amplitude spectrum is substantially uniform over the main part of the video bandwidth, whereas a 2T pulse contains little energy above 3·3 MHz and none in the 5 MHz range. Reference 4 describes the digitisation of these waveforms and the computer programme developed to analyse the data.

In order to record the effects of any impairments of the Teletext waveform, photographs were made of the Teletext waveform and the Teletext eye pattern. Reference 5 discusses measurement of the Teletext waveform and describes equipment similar to that used, during the tests in Germany, to give a display of the Teletext eye pattern.

Teletext decoders, whose performances had been calibrated, were used to provide further checks on the quality of the received Teletext signal. These tests enabled the effects of ignition interference and other forms of impulsive and r.f. interference to be studied. They also ensured that effects not readily observed from waveform photographs did not pass unnoticed.

Two laboratory Teletext decoders, one provided for the tests by the IBA and the other by the BBC, were equipped with error monitoring facilities. These enabled the total number of corrupt frame-codes and character parity-errors, received in a 10 s interval, to be counted. Further, at the beginning of each line of Teletext data, the character pair 'SM' was generated by the CEEFAX source (i.e. the BBC Teletext source).* This 'SM' sequence was thought, at the time, to be the most susceptible to channel distortion. The laboratory decoders were equipped to count any errors corrupting this particular data sequence.

Tests using decoders were also made to augment other site measurements. The u.h.f. signal from the receiving aerial was progressively attenuated so as, correspondingly, to reduce the signal-to-noise ratio. Then, by relating

(a) the video signal-to-noise ratio,

(b) the u.h.f. signal level,

(c) the attenuation of the signal from the aerial,

(d) the errors in the decoded Teletext signal and

(e) the eye-height of the received Teletext waveform,

a complete series of cross-checks could be made on the results.

3. The trials system and test procedure

3.1. The overall system

In this Section the test arrangements are described and the critical components of the signal origination, signal reception and signal measuring equipment are defined. It also outlines the test procedures.

The general arrangement of the trial system is illustrated in Fig. 1. The signal origination equipment, including the Teletext data sources, the IRT Data Line Generator and the insertion test-signal generators, was located at the IRT laboratories. The receiving, data-

* A complete description of the CEEFAX source used in the tests in Germany appears in Appendix 1.

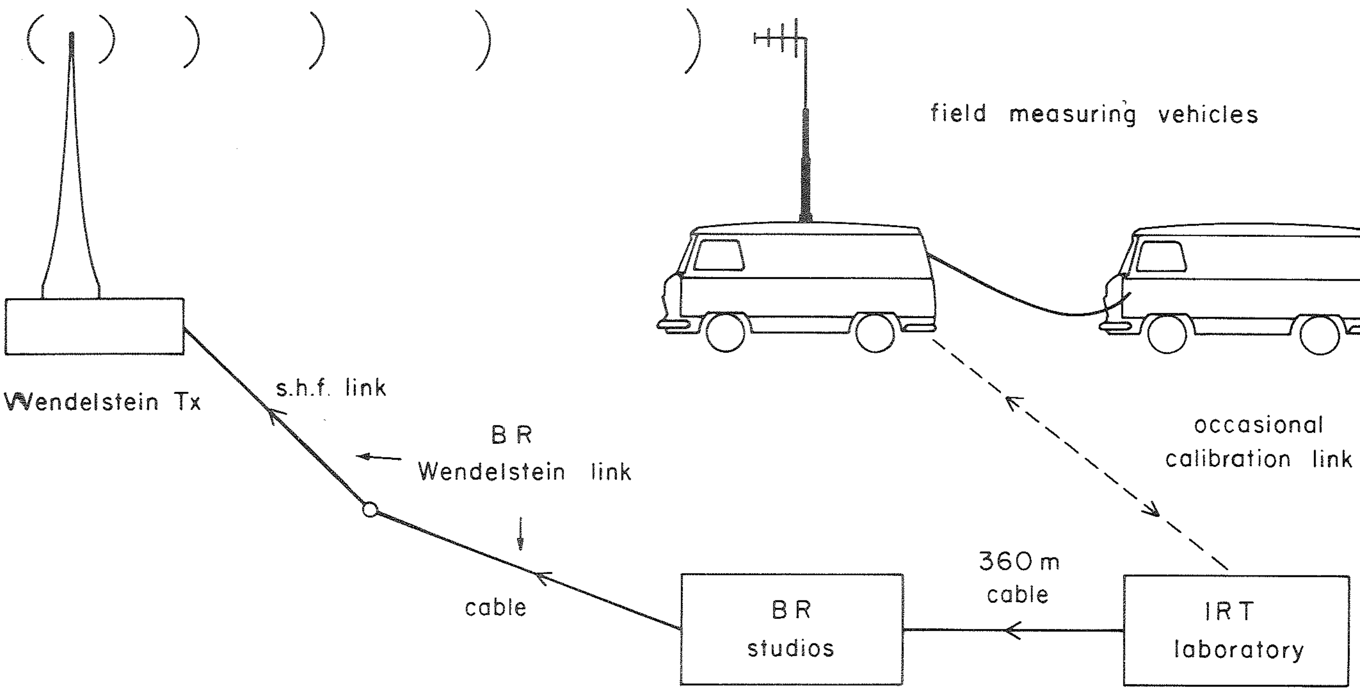


Fig. 1 - General arrangement of the trial system

decoding, and signal-quality measuring equipment was installed in two IRT mobile laboratories for the field tests.

For the duration of the tests a video 'test card' signal was originated by the IRT, with the test signals, described in detail in Section 3.2, inserted into the field-blanking interval. The signal was then conveyed to the Wendelstein transmitter, using the network normally used for Bayerische Rundfunk television programme 1. (Complete descriptions of the network path and the transmitter are given in Sections 4.1 and 4.2 of this report, together with an analysis of their performances.)

3.2. Test signal origination equipment

3.2.1. General

The test signals were inserted in the field-blanking interval as shown in Fig. 2 and listed below.

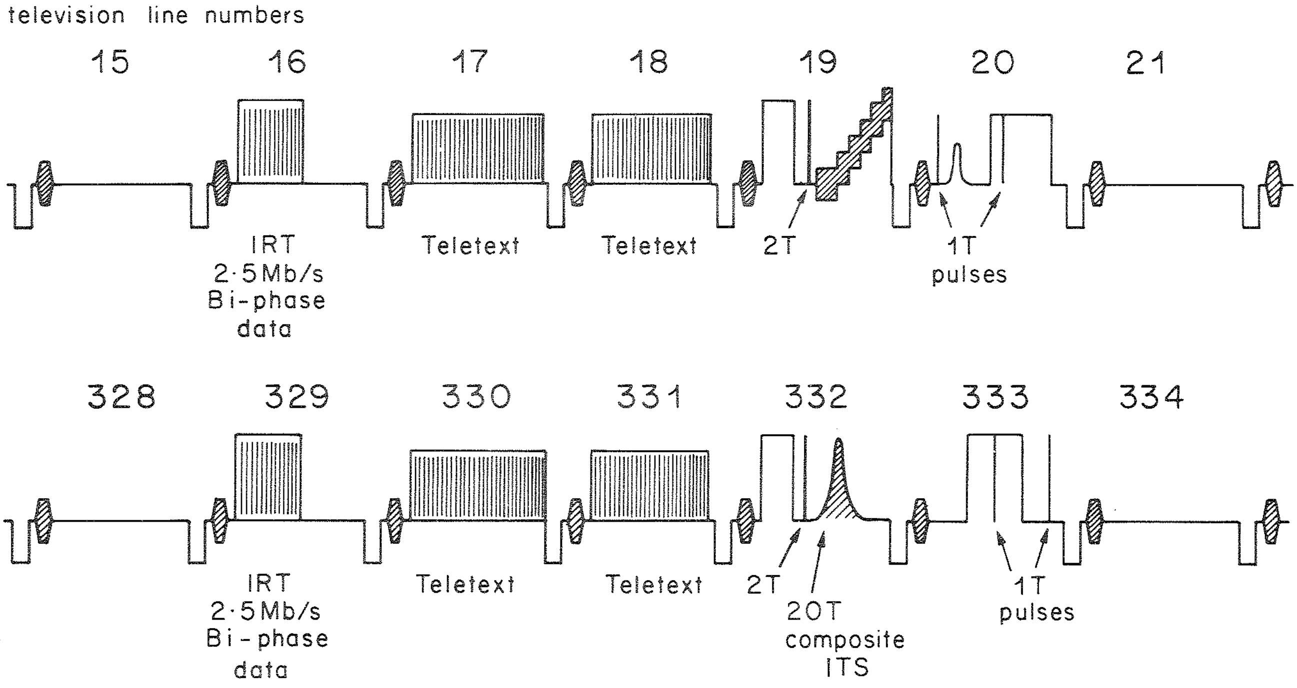


Fig. 2 - Test signals in the field-blanking interval

Line 16, 329 – 2·5 Mb/s bi-phase data from IRT data source, nominal data level 0·7V.

Lines 17, 18, 330, 331 – Teletext data signals, nominal data level 0·5V.

Line 19 – insertion test-signal, including 2T pulse and bar, and chrominance staircase.

Line 332 – insertion test-signal inlcuding 2T pulse and bar, and 20T chrominance pulse.

Line 20 – 1T pulse-and-bar test-waveform, bar amplitude = 0·5V.

Line 333 – 1T pulse-and-bar test-waveform, bar amplitude = 0·7V.

The apparatus used to generate these signals is described in more detail in the following sub-sections.

3.2.2. IRT data source

The IRT 2·5 Mb/s bi-phase Data-Line signal was provided by an IRT Data-Line generator and was inserted in line 16 (329). This equipment supported concurrent trials, by the IRT, of their Data-Line system.

The tests conducted with this system are not reported here.

3.2.3. Teletext data source

The CEEFAX 'Test Pages' generator is described in Appendix 1. It was used as a source for the field trials because rows from adjacent pages of information and separate rows within one page are readily identified. Hence, when noise or interference causes rows of information to be misplaced or results in the display of rows from pages not selected these errors are plainly visible.

The data-signal waveforms produced by the Test-Pages generator are described in Reference 1. A 4·6 MHz low-pass filter was used to truncate the signal spectrum and the response of the truncating filter and photographs of the data eye-pattern at the output of the Teletext data source appear in Appendix 1.

3.3. Receiving and data-decoding equipment

3.3.1. The two test vehicles

As mentioned earlier the receiving and data-decoding equipment was installed in two IRT mobile laboratories. The arrangement of the equipment is shown in Fig. 3(*a*). One of these vehicles (the 'r.f. and video vehicle') was fitted with a v.h.f. aerial mounted on a pneumatic mast. This vehicle contained aerial distribution equipment, v.h.f. receivers and waveform-display apparatus. The other vehicle (the 'data vehicle') was fitted with data decoders and a high-quality picture monitor. A video co-axial cable was used to provide a video feed from the r.f. and video vehicle to the data vehicle, and two-way communication was provided between the separate vehicles. Each vehicle was fitted with an independent supply of electrical power; a petrol-electric generator in the r.f. and video vehicle and a diesel-electric generator in the data vehicle.

3.3.2. Aerial and v.h.f. distribution system

In this part of the test system, professional quality apparatus of good calibrated performance was used to simulate conditions that might be expected in a good domestic installation.

The polar diagram of the aerial used in the tests, and the recommended minimum standard for a domestic aerial are shown in Fig. 4. The main differences between these characteristics are that the overall rejection of off-axis signals was slightly better and the gain 0·5 dB greater for the aerial used in the tests, however, it was not expected that this would affect the significance of the results.

The v.h.f. aerial signal was amplified by a pre-amplifier to produce a signal of higher level than would normally be provided by the aerial itself. This ensured that the major noise contribution was from the pre-amplifier rather than from the separate receiver front-ends, and thus would not vary from receiver to receiver. By attenuating the aerial signal prior to the common pre-amplifier the signal-to-noise ratio could be decreased to simulate a lower field-strength receiving condition. In this way the relationship between v.h.f. field-strength and demodulated video signal-to-noise was determined substantially independently of the individual noise factors of the v.h.f. receivers used. Fig. 5 shows a comparison of the v.h.f. system used in the tests with a typical domestic installation (based on a DBP report[6]) and gives details of the losses and noise figures in each case. It will be seen that in order to make the test arrangement equivalent to a typical domestic receiving installation, an aerial attenuation of some 5 dB was required.

A derivation of the relationships between field-strength, signal level and video signal-to-noise ratios are included in Appendix 2.

3.3.3. VHF receivers

As outlined in Section 2.4 a professional video receiver of good calibrated performance was used during the tests. This receiver was a fixed-tuned prototype device. In addition to its synchronous video-detector, which was used at most test sites, the receiver was also fitted with an envelope detector which was used for comparative tests at a few sites. Calibration results obtained with this receiver are given in Appendix 3.

At each site visited the signal strength was measured with a field-strength measuring receiver which was calibrated by the IRT to within 0·5 dB.

A commercial System B television receiver with an integral prototype Teletext decoder was prepared for the tests as indicated in Appendix 4. This was a current design of receiver, with an enhanced-carrier video-detector, which had been provided with video response-correction circuits.

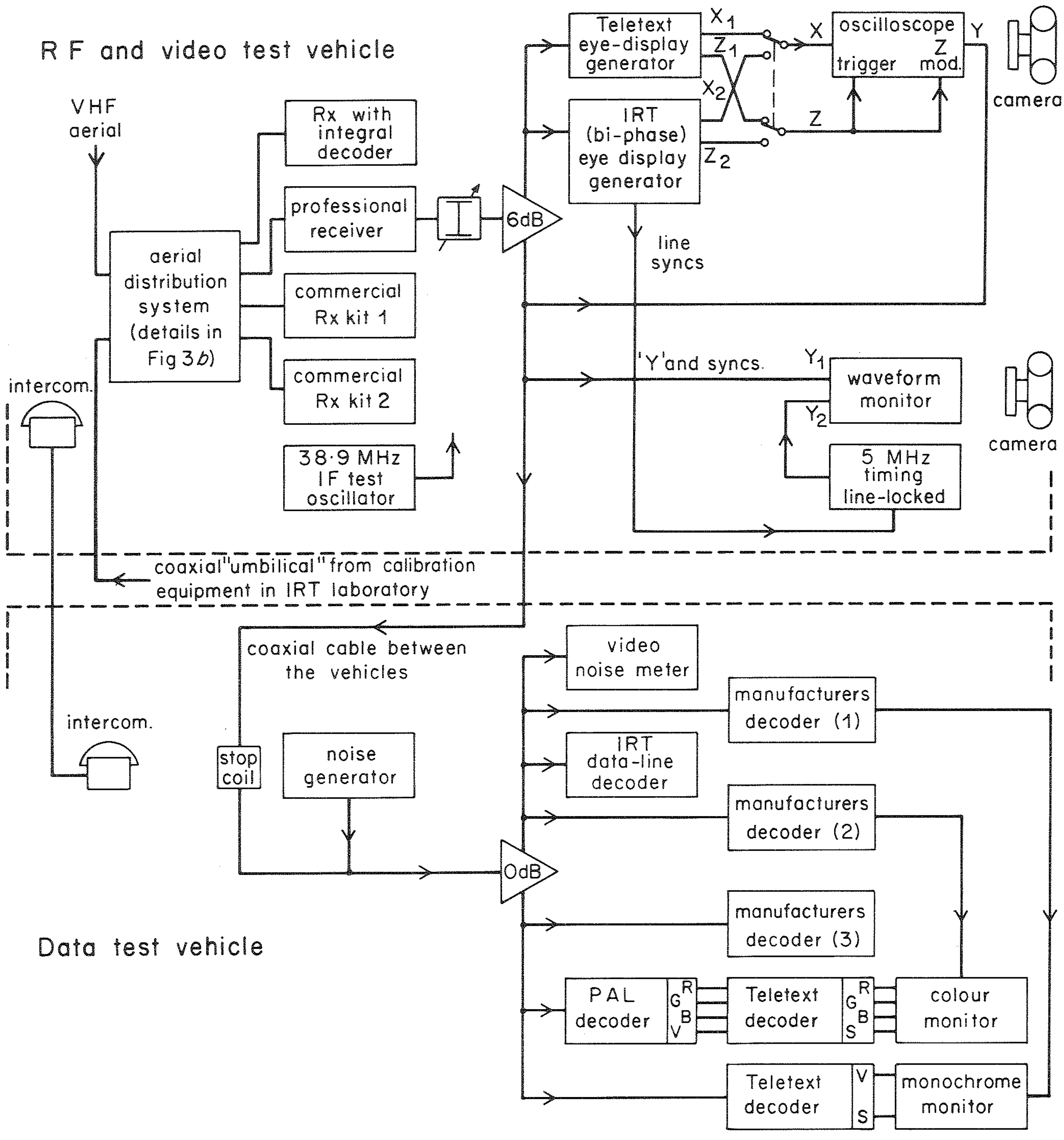


Fig. 3 - Arrangement of the equipment in the field test vehicles

(*a*) The division of the measuring equipment between the two field test vehicles

The measured performance of this receiver is included in Appendix 4.

In addition, two sets of current System B television tuner/i.f. panels with enhanced-carrier video-detectors were provided by British manufacturers for the tests. The performances of these are described in Appendix 5, and the data is used later in this report in an attempt to predict the performance of a typical future domestic television receiver fitted with a Teletext decoder.

Tuning of the variable-frequency receivers was achieved using a 38·9 MHz oscillator whose output was coupled by means of a radiating loop to the receiver i.f. circuit. At the correct tuning position a near zero-frequency beat was observed at the detected video output.

3.3.4. Teletext decoders

As described in Section 2.4 two laboratory Teletext decoders with special error-counting facilities were used in

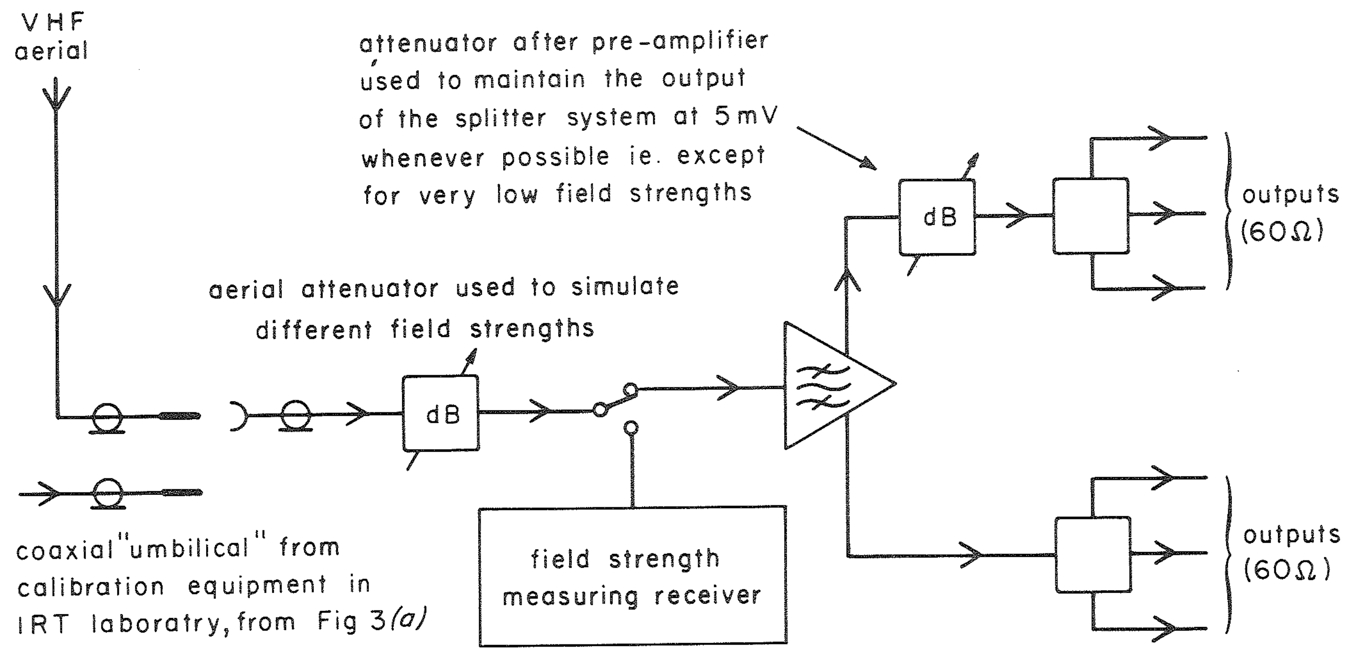


Fig. 3 - Arrangement of the equipment in the field test vehicles
(*b*) Details of the aerial distribution system

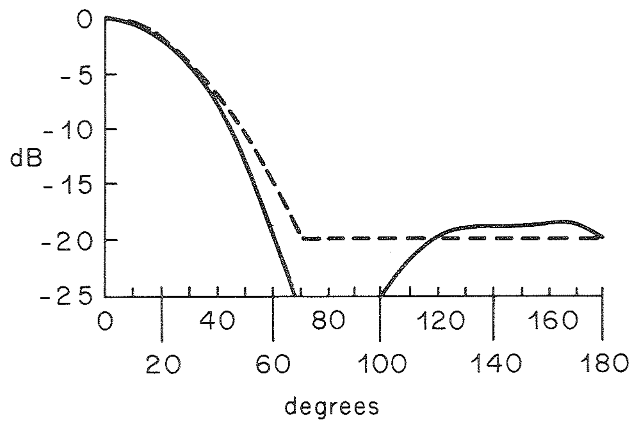


Fig. 4 - Polar diagram of receiving aerial
——— Aerial used in the tests
– – – Recommended minimum standard for a domestic aerial

the tests. In addition, prototype Teletext decoders were provided by British manufacturers. The performances of these decoders are described in Appendix 6.

3.3.5. Video signal-to-noise ratio meter

This was provided by the IRT and gave a digital display of the r.m.s. unweighted noise (dB relative to peak picture-signal level) measured during an unused line in the field-blanking interval. The measurement was displayed in units of 0·1 dB and the overall accuracy was ±0·25 dB for signal-to-noise ratios between 10 and 50 dB.

3.4. Procedures used at site tests

Four different procedures were used for the site tests. This enabled the relatively short transmission time to be used as effectively as possible. The four main types of tests adopted are summarised below.

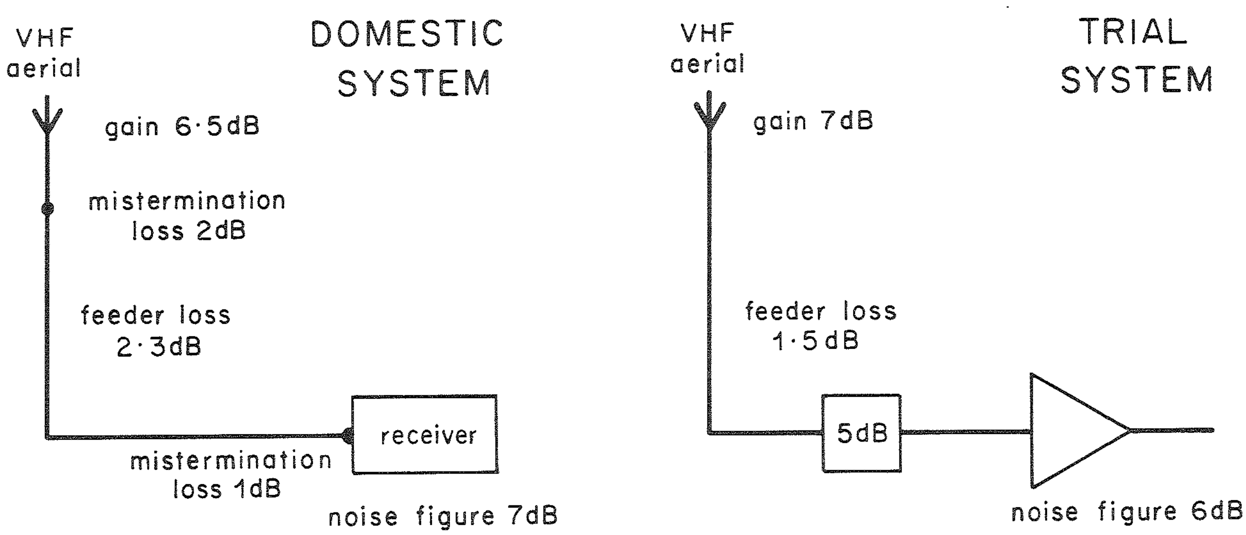


Fig. 5 - Comparison of a typical domestic installation with the v.h.f. system used in the tests

VHF SYSTEM B TESTS IN GERMANY

Site: ②	Rx:	Date: 16·4·75	Time: 12·18

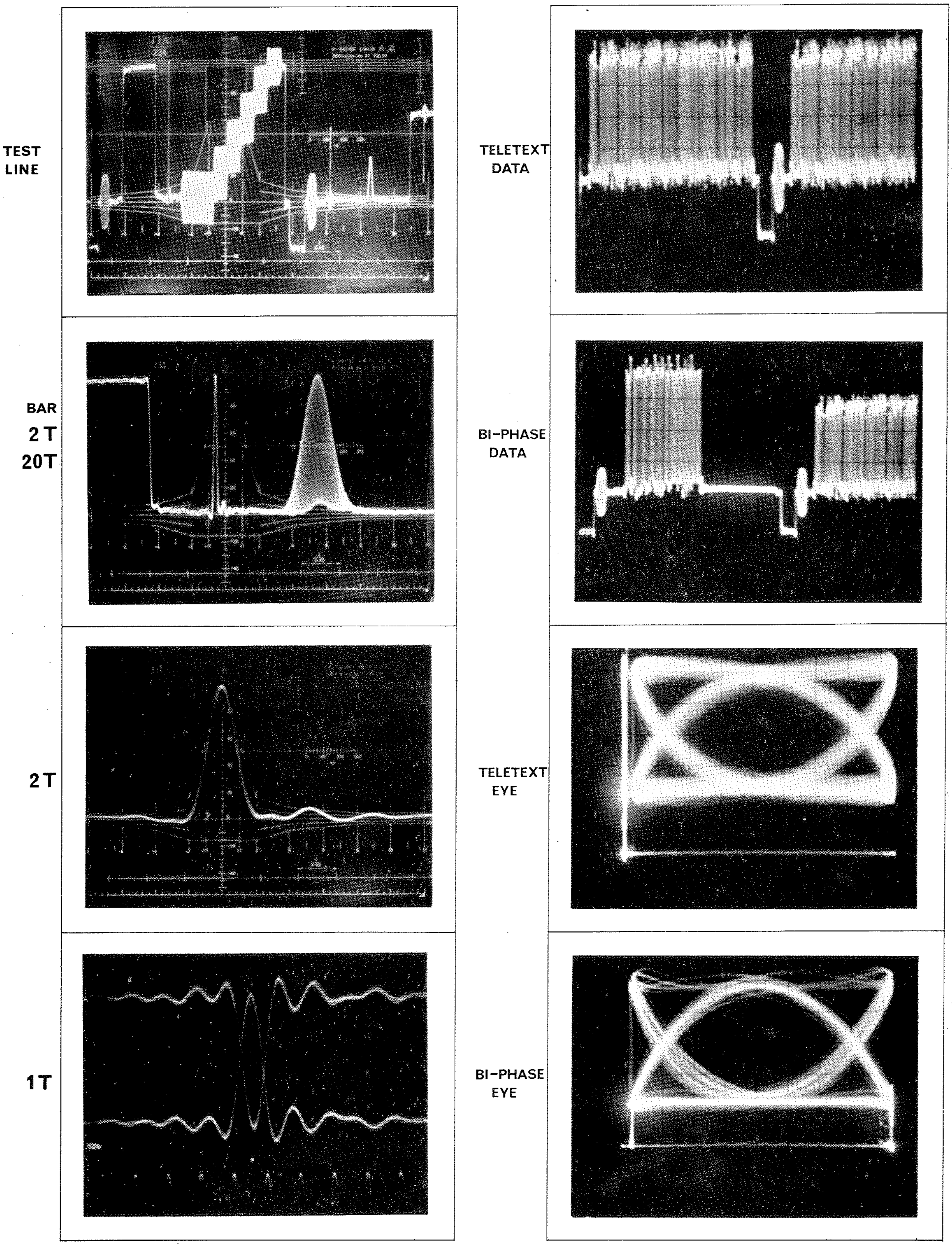


Fig. 6 - An example of the photographs taken at each site

(a) 'Full' tests. First, the v.h.f. signal strength was measured. Then a set of photographs of the field-interval waveforms was taken, as illustrated in Fig. 6, using the video output from the high-quality professional vision receiver. This video signal was also applied to a picture monitor, for subjective grading, and to the laboratory Teletext decoders, where error checks were made. (Errors were plotted as a function of the picture signal-to-noise ratio, which was progressively reduced by attenuating the v.h.f. signal from the aerial.)

Tests were also conducted using the commercial receiver with the integral prototype Teletext decoder. The picture was graded and the various values of attenuation applied to the v.h.f. signal, which gave Teletext performances corresponding to the criteria C and D shown in Table 3 were noted.

(b) 'Brief' tests. These required the use of only one measurement vehicle. The received signal quality was recorded photographically, using the professional receiver, and the Teletext reception was assessed using the commercial receiver with the integral Teletext decoder. The tests were conducted as for (a) above, but the output of the professional receiver was neither graded nor applied to a Teletext decoder.

(c) 'Domestic' tests. For these tests the commercial receiver with integral Teletext decoder, together with a v.h.f. attenuator and aerial amplifier were taken to flats in the residential areas of urban Munich. The v.h.f. signal available in each flat, provided in every case by a communal aerial distribution system, was tested by noting the attenuations required to give Teletext reception according to criteria C and D. As a rough check on signal strength the noisy picture produced by attenuating the v.h.f. signal was graded.

(d) 'Manufacturers' tests. These tests were conducted as 'full' tests but, in addition, tests were made with the receiver and decoder units provided by British manufacturers. The waveforms at the output of each receiver were photographed as illustrated in Fig. 6. Each received video signal was then applied to the prototype Teletext decoders, and the data reception was tested using a procedure similar to that described in (a) above for the commercial receiver with integral decoder.

The commercial receiver with integral prototype decoder was not present for the 'Manufacturers' tests as these were concurrent with the 'Domestic' tests described in (c) above.

4. Analysis of the results

4.1. The signal chain to the Wendelstein transmitter

For the duration of the tests, the signal path normally used for Programme 1 of Bayerische Rundfunk was extended to the IRT laboratories and used to convey the test signals to the Wendelstein transmitter. This signal path included a number of cable sections and an s.h.f.-link section.

Prior to the tests, IRT engineers conducted measurements of the television waveform along this signal path. For these measurements the 1T pulse and bar waveforms were originated from the IRT building and measured and photographed at the input to the Wendelstein transmitter.

The results of these measurements showed that, overall, the performance of this signal chain was good, the only significant signal distortion being a reduction in the amplitude of colour subcarrier by about 1 dB. Analysis of the positive and negative 1T waveforms (using the techniques described in Reference 4) gave mean results for the amplitude/frequency and group-delay/frequency characteristics as shown in Fig. 7.

4.2. The Wendelstein transmitter

4.2.1. Transmission characteristics

The main transmission characteristics for a System B (Germany) transmitter are listed in Section 1 of the report.

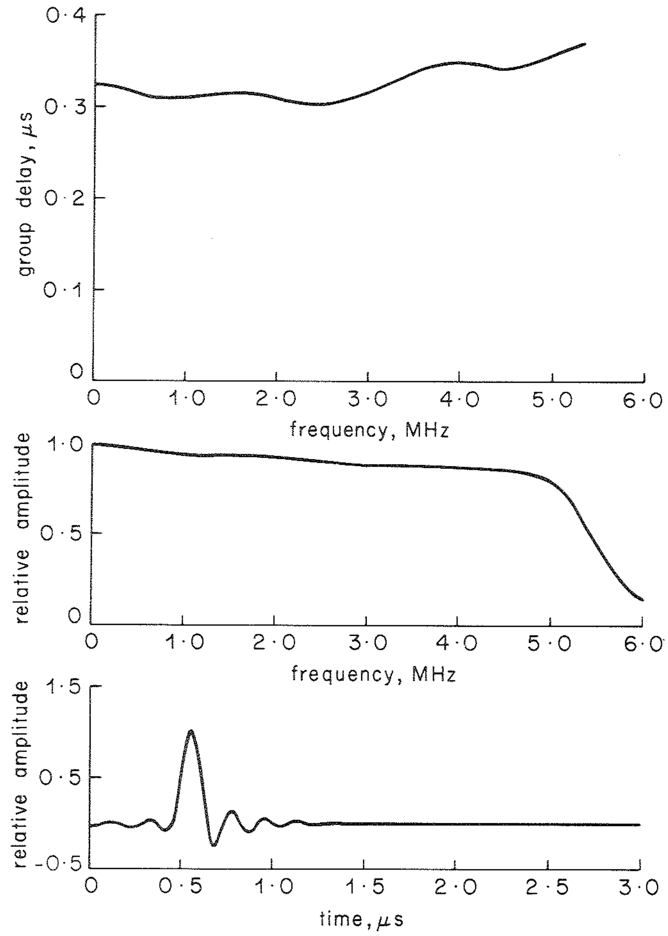
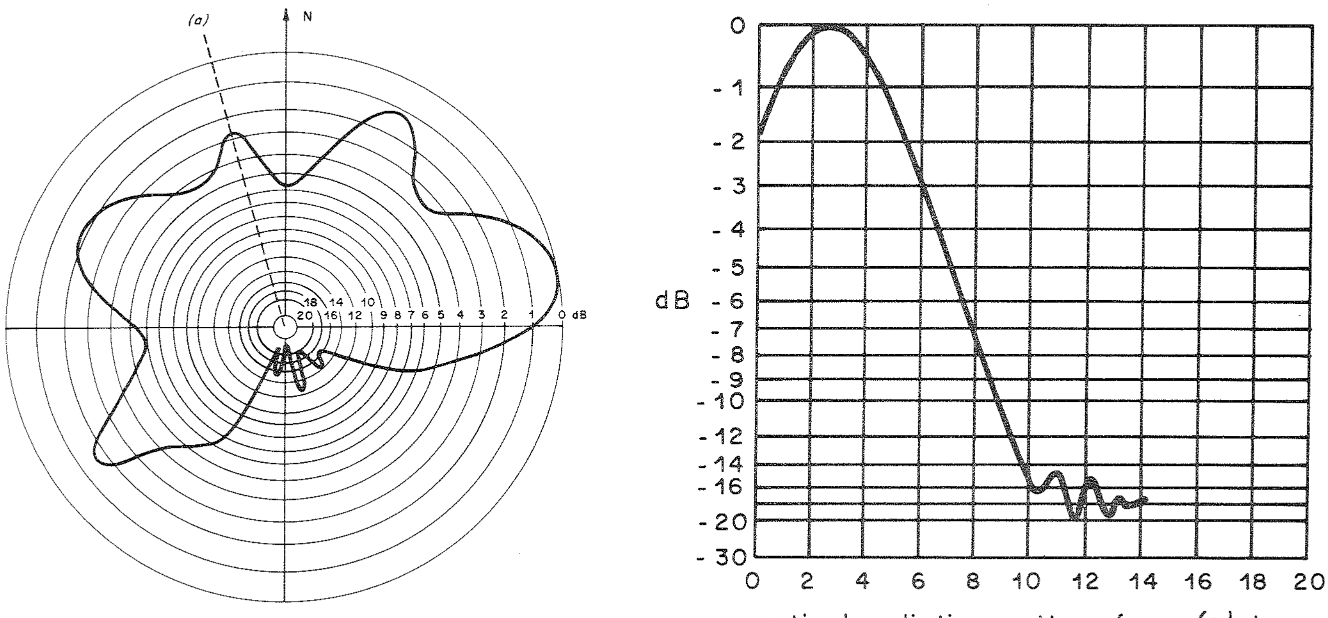


Fig. 7 - Computed performance of the programme chain from the IRT building to the Wendelstein transmitter



horizontal radiation pattern

vertical radiation pattern from (a), degrees

Fig. 8 - Polar diagram of the Wendelstein transmitter aerial

Other important characteristics specifically relating to the Wendelstein transmitter are given in Table 4 below:

TABLE 4

Characteristics of the Wendelstein Transmitter

Polar diagram	Approximate cardioid (Fig. 8)
E.R.P.	100 kW (Vision)
Mean height of aerials	1869 m (above sea level)
Height of base of mast	1825 m (above sea level)
Vision carrier frequency	210·260416 MHz (±100 Hz)

4.2.2. Measured performance

Measurements of the performance of the Wendelstein transmitter were conducted by the IRT prior to the tests. A 1T-pulse waveform was applied to the input of the transmitter and various receivers were connected to the test probe output of the transmitter. The demodulated outputs were plotted and photographed.

Unfortunately only one plot and one photograph of the demodulated output waveform were obtained using a truly synchronous detector, and the time-scale used was such that they could not be accurately analysed. Hence deductions could be made only by direct observation.

The photograph showed about 1 dB attenuation of the chrominance signal and a 1T-pulse height of about 70%.

Further information about the performance of the transmitter can be deduced from tests conducted at two 'clean' sites. At these sites Teletext eye-heights of about 68% were measured at the output of the professional high-quality receiver (analysis of the 1T waveforms for these sites confirmed this figure), as compared with 71% for the same receiver using a test modulator. However, analysis of these waveforms and results at many different sites also revealed an echo in the transmitted signal, estimated to be about 7% in relative amplitude and delayed by 500 ns. Overall, the linearity of the transmitter was good and, on the basis of the measurements made, good Teletext transmissions were to be expected.

4.2.3. Observations made of the transmitter performance during the preliminary tests in Germany

During the preliminary tests, carried out in Germany in December 1974, it was not possible to make accurate measurements of the output from the Wendelstein transmitter because no receiver with a synchronous detector was available. Using a domestic receiver (with envelope detection and modified to have a video output) connected to a BBC laboratory-prototype decoder, Teletext reception was possible at all three sites visited. This result was obtained despite the fact that the receiver, when measured later, was found to have a poor Teletext performance.

On one occasion, during the preliminary tests, the transmitting aerial was found to be badly affected by ice during the early part of the morning. In this condition the signal received at the IRT was so badly distorted that the Teletext waveforms were unrecognisable.

4.3. The service area and distribution of sites tested

The transmitter used in the tests is situated some 60

km south east of Munich, near the summit of the Wendelstein Mountain on the edge of the Bavarian Alps. The approximate service area of the transmitter and some relevant height contours of the area are shown in Fig. 9. Fig. 10 shows a section from the Wendelstein through Munich. From these it can be seen that this transmitter serves a particularly large area because of its elevated site and because the area served is fairly flat. The service area is bounded approximately by the 500 m contour and the Alps.

The population distribution within the service area is illustrated in Fig. 11. The total population is about 2,700,000 and is concentrated mainly in Munich (1,340,000) Augsburg (260,000), Landshut (56,000) and Rosenheim (38,000).

The distribution of sites tested is shown in Fig. 12. It shows that a large proportion of the tests were conducted in and around Munich. (It was not possible to carry out tests with the mobile laboratories in the central area of Munich because here the buildings were considerably taller than 10 m – the height of the test aerial.) Three tests were conducted in the centre of Augsburg and most of the remainder were conducted in towns served exclusively by the Wendelstein transmitter. These sites were selected according to the criteria discussed in Section 2.2 of this report. A small group of tests, shown at the southern extremity of the service area, were made in an area of sparse population which is served, in part, by a transposer relaying the Wendelstein transmissions.

4.4. The observed instances and effects of multipath

4.4.1. General

For this analysis of the results, attempts were made to isolate effects directly attributable to multipath propagation from effects caused by interference, which are dealt with later in this report.

The analysis is concerned with the effects of multipath propagation on Teletext transmissions when professional-quality receivers (with synchronous detectors) and decoders of good performance are used. Later sections of this report will discuss the modification of these results so as to represent reception in a domestic Teletext installation.

From the results of 23 sites where 'Full' tests were conducted, 9 sets of results have been selected for detailed study. (These are the sites where no interference effects were noted and the received-signal strength and quality was found to be consistent for the duration of the test.)

4.4.2. Relationship between subjective picture grade and Teletext eye-height at selected sites

The measured Teletext eye-heights and approximate picture grades for the nine sites selected as above are shown in Fig. 13. The grade definitions appear in Table 5. It will be seen that there is poor correlation between these two sets of results.

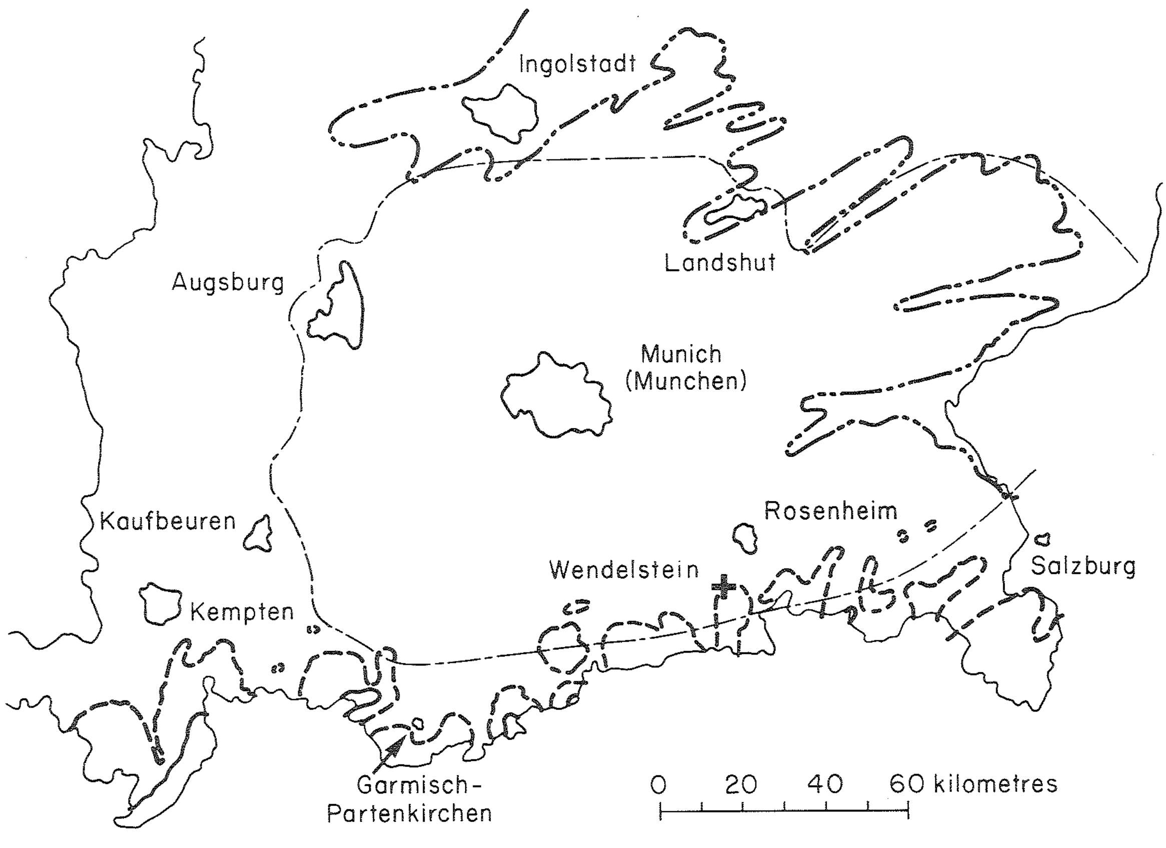


Fig. 9 - Approximate service area of the Wendelstein transmitter showing relevant height contours

Height contours —·— 500 m – – – 1,000 m ——— 2,000 m ——– – Approximate limit of service area

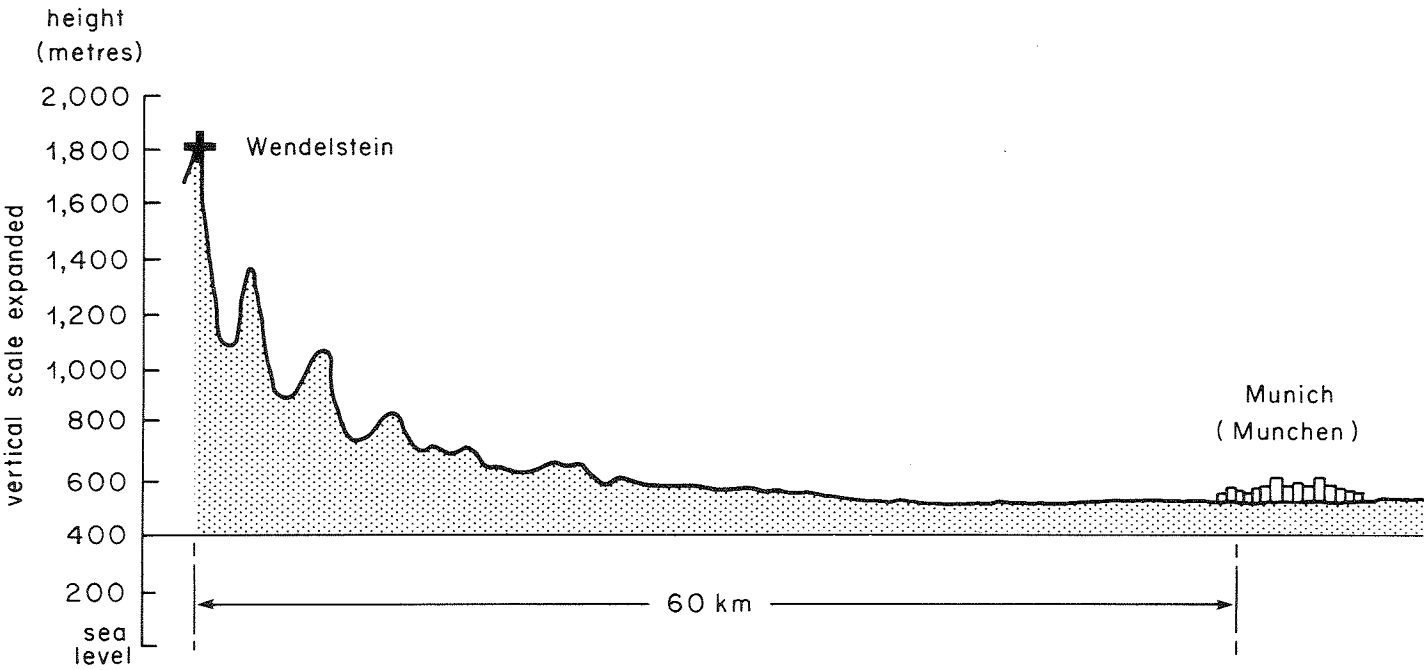


Fig. 10 - A section from the Wendelstein transmitter through Munich

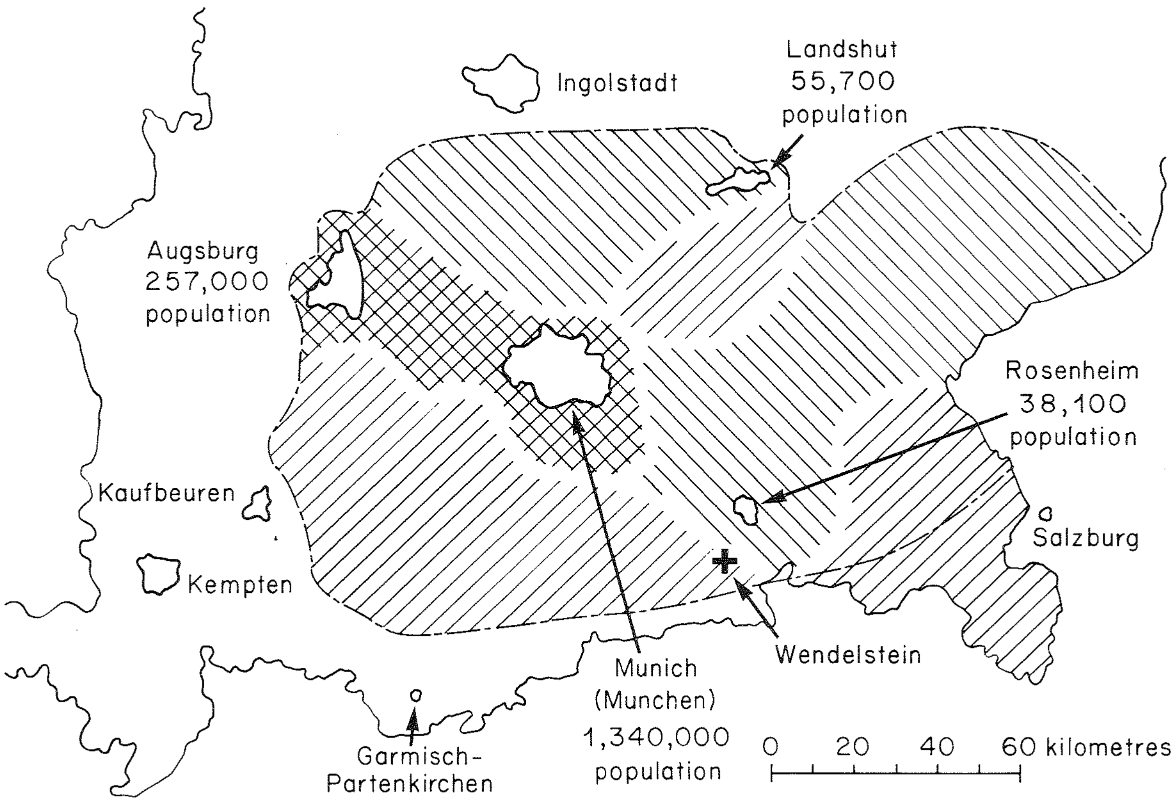


Fig. 11 - Population distribution within the Wendelstein service area

Approximate limit of service area

Mean population densities: 50 to 100 per square kilometre; 100 to 200 per square kilometre; 200 to 300 per square kilometre

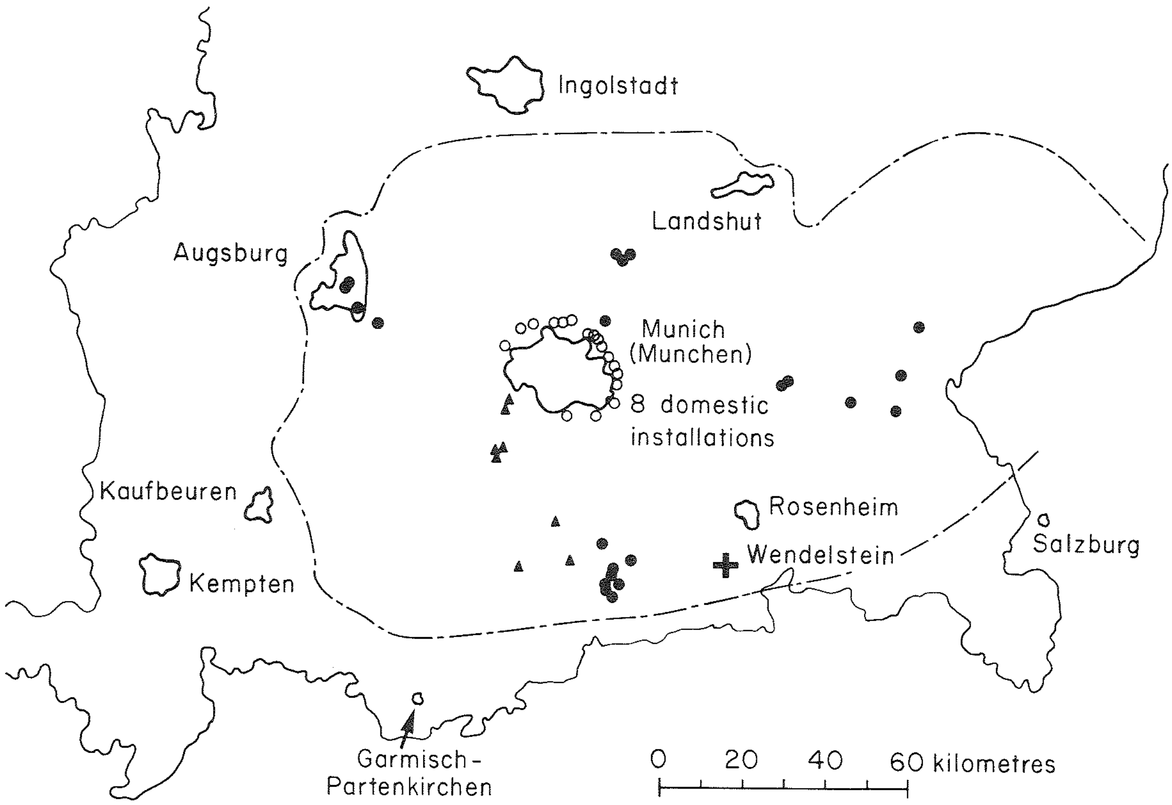


Fig. 12 - Distribution of sites tested

— - — - — Approximate limit of service area

● Full test sites ○ Brief test sites ▲ Full test sites where commercial receiver/decoder not present

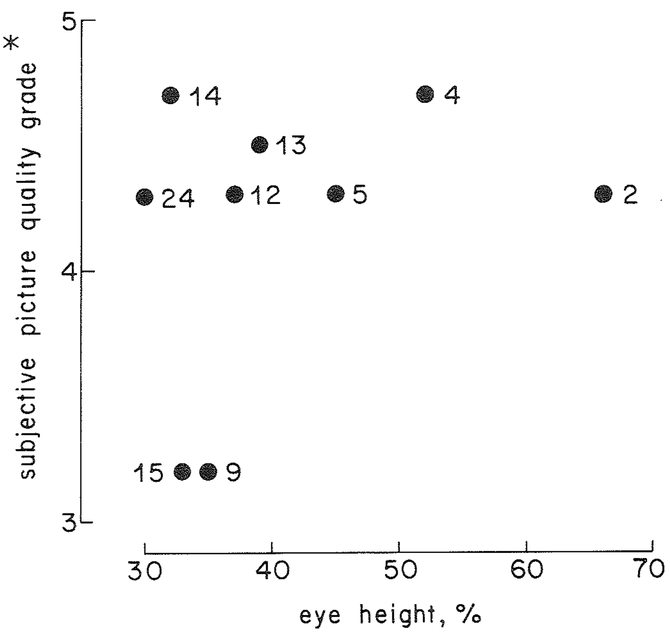


Fig. 13 - Subjective picture grade and Teletext eye-height at selected sites*

● site no.

* Subjective assessments of picture grades were conducted under difficult conditions in the mobile laboratories by three observers and can only be taken as approximate.

TABLE 5

CCIR PICTURE GRADES		
Grade	Quality	Impairment
5	Excellent	Imperceptible
4	Good	Perceptible but not annoying
3	Fair	Visible, slightly annoying
2	Poor	Annoying
1	Bad	Very annoying

Inspection of the waveform photographs for these sites shows that the main effects of multipath reception which reduced Teletext eye-height were closely-spaced positive echoes that would not be expected to cause significant impairment of the picture. For sites 9 and 15 multiple echoes including some with relatively long delays were visible in the waveforms.

The fact that the predominant effects of multipath reception at the sites tested were found to be due to

closely-spaced positive echoes may have partly arisen because the aerial was adjusted, at each site, for maximum signal strength; this adjustment may well have favoured the reception of positive echoes.

4.4.3. Relationship between Teletext eye-height and Teletext performance at selected sites

In Reference 5 it is suggested that eye-height is a good measure of ease of decoding the received signal. In this section of the report the relationship between Teletext eye-height and the probability of parity error as a function of video signal-to-noise ratio is defined. This relationship can then be used to assess the combined effects of multipath and low v.h.f. signal level.

In the course of 'Full' site tests parity errors were recorded at different picture signal-to-noise ratios. Fig. 14 shows the results for the nine selected sites, and for other results obtained in the course of calibrating the decoders (when reduced eye-height signals were generated by synthesising multipath effects at video, and adding locally-generated electronic noise to the signal). Each curve refers to the results obtained at one particular site or test condition; the measured eye-height is shown adjacent to each curve. From Fig. 14 it can be seen that where the eye-height is high, the signal-to-noise ratio for a particular error rate is low. Curves of error rate versus signal-to-noise ratio can be used to predict the number of errors which might be expected at a given signal-to-noise ratio and a given eye-height.

4.4.4. Distribution of eye-height for all sites

In this analysis most eye-height measurements at sites have been included. In cases where the signal quality changed in the course of a site test, the eye measurement was taken as a measure of the signal quality at a particular instant.

Eye-pattern photographs were taken of the waveform from the professional receiver, with synchronous detector, at 44 sites. At one site the aerial was redirected to improve the eye-pattern but, for the present investigation, that result has not been included. In addition the results not used included those from site 1, where instrumentation problems were present, nor from site 23, where an alternative service was available and no domestic installations were observed to be using the Wendelstein service.

For the remaining 42 sites the average eye-height is 44%. A graph giving the cumulative percentage of the eye-height results as a function of eye-height has been plotted on arithmetic probability paper (Fig. 15). This curve indicates a Gaussian distribution and suggests that, for the selection of sites tested:

(i) the percentage of sites with less than 30% eye-height = 12%

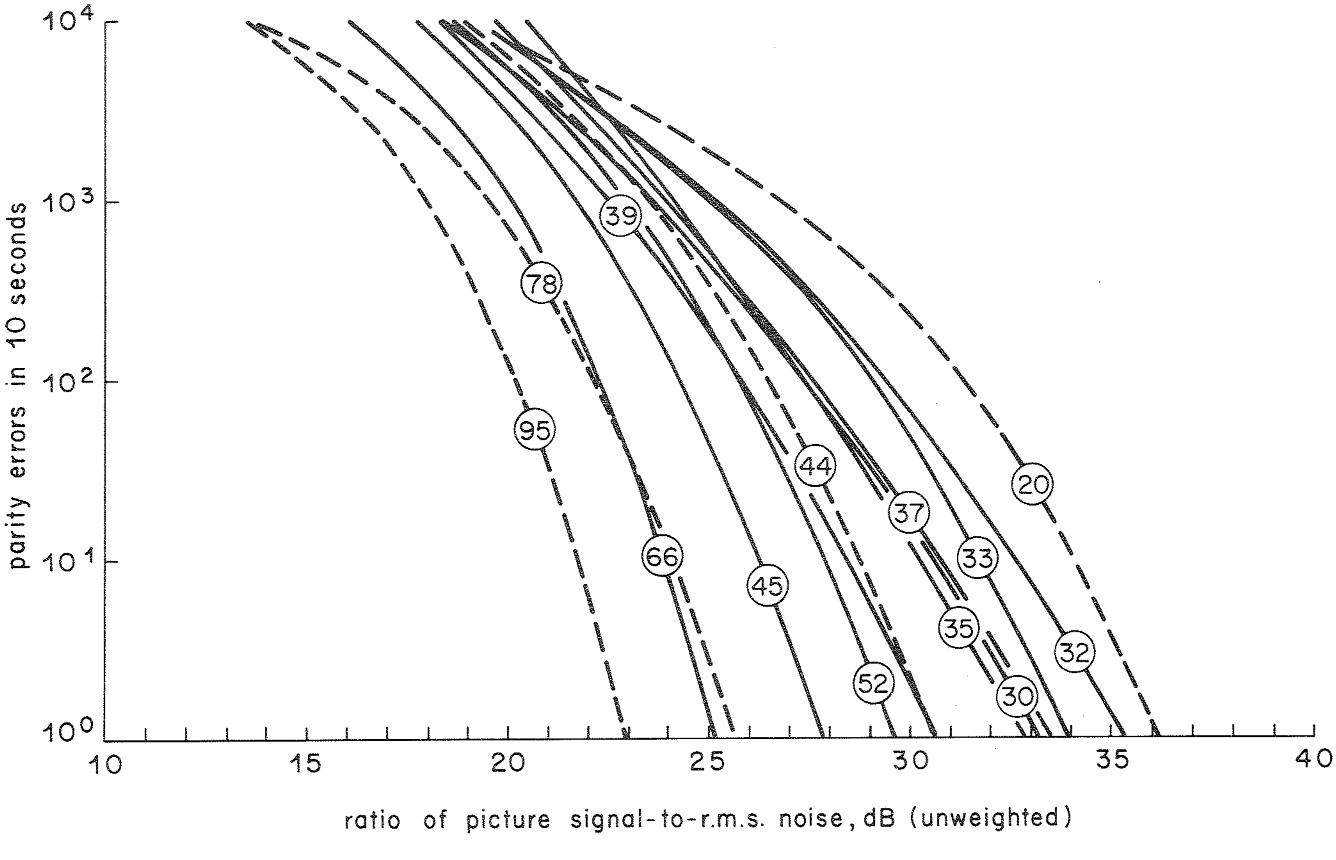


Fig. 14 - Practical relationship between parity errors and signal-to-noise ratio at different eye-height

(95) measured eye-height % —— nine selected sites (see text)
– – – – synthesised multipath conditions produced in the laboratory

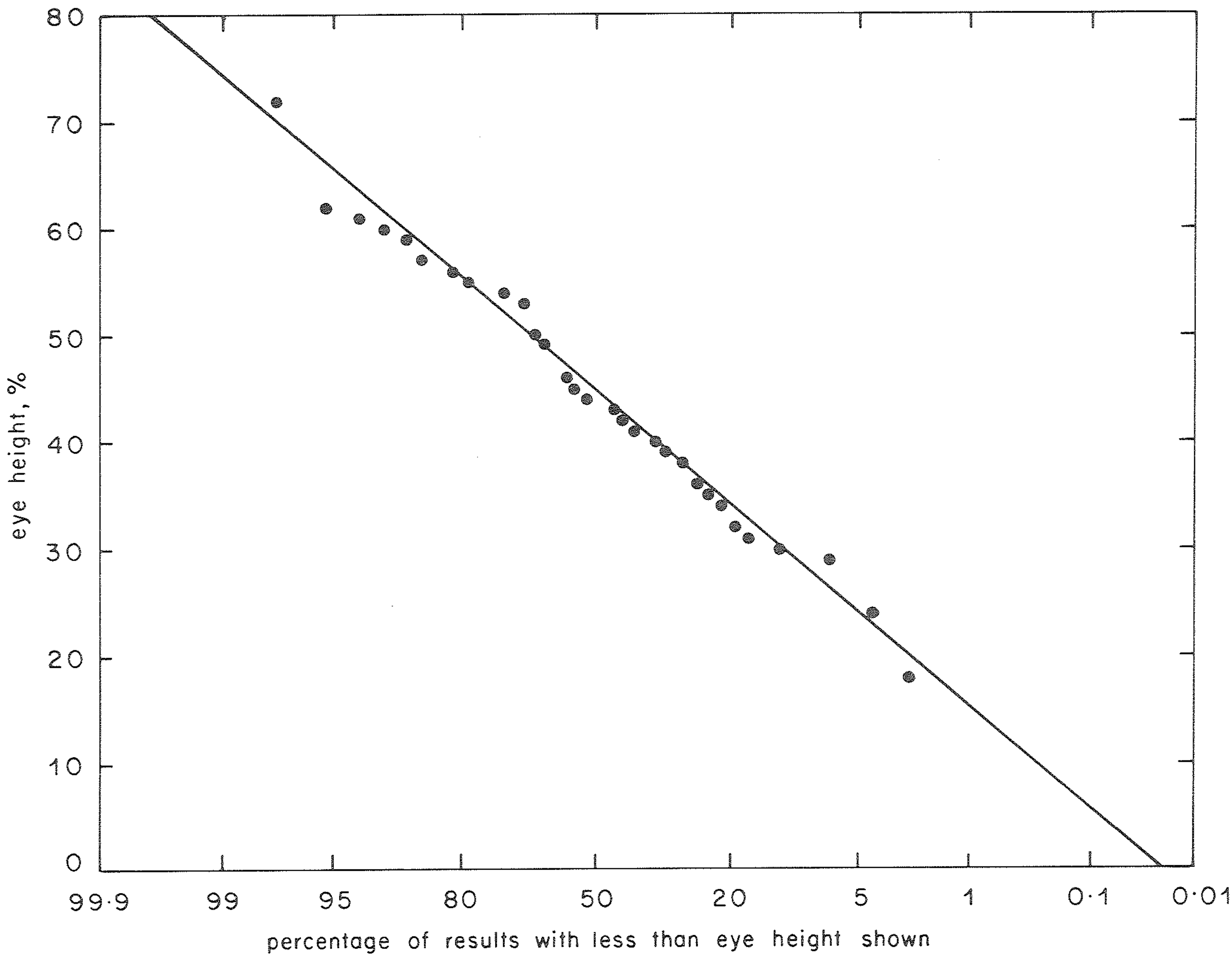


Fig. 15 - Cumulative percentage of results having less than a given eye-height

(ii) the percentage of sites with less than 20% eye-height = 3%.

4.4.5. Total effects of multipath on Teletext reception

Combining the results quoted in Sections 4.4.3 and 4.4.4, and referring back to Table 3, the following conclusions can be drawn regarding a site with the average 44% eye-height:

(i) Error-free Teletext reception for 3 consecutive acquisitions (criterion B) is just possible given a picture signal-to-noise ratio of 30 dB (unweighted). In these tests this corresponds to a field-strength of 58 dB μV/m (see Appendix 2).

(ii) There will be no Teletext errors remaining after two writes of one page (criterion C) given a picture signal-to-noise ratio of 24 dB (unweighted). In these tests this corresponds to a field-strength of 52 dB μV/m (see Appendix 2).

4.5. The observed instances and effects of ignition interference

4.5.1. General

In Teletext field trials, conducted in the U.K. at u.h.f. ignition interference was not found to be a problem, however it was anticipated that the effects of ignition, and other interferences, might be greater at v.h.f. because of the lower frequency and because v.h.f. aerials have, in general, poorer directional characteristics than u.h.f. aerials.

4.5.2. Observations

As the field tests described in this report were conducted using mobile laboratories, most tests were conducted adjacent to roads; in fact, some tests were conducted very close to major roads carrying heavy traffic. Hence, any survey of the instances of ignition interference would tend to be pessimistic; however, the greater number of instances of such interference would provide opportunities for any effects to be studied.

Initial observations showed that a small burst of parity errors occasionally occurred when a car passed the test site. Such bursts of errors were accompanied by interference visible on the picture, the visible interference being very much more frequent than the bursts of errors.

Of the 44 sites tested, ignition interference effects were visible on the picture at 17 sites and Teletext reception was

impaired at 13 sites. It was noted that when the signal from the aerial was attenuated, a small number of errors could occur when, with no ignition interference, the signal level was still adequate for error-free reception.* This effect was due to the interference pulses having insufficient amplitude to cause errors until a low level of random noise was also present. In six of the 13 cases some errors were received with no attenuation of the v.h.f. signal; these occurred in bursts of up to 20 errors and ranged from one to 11 errors in 10 s.

4.5.3. The effect of ignition interference on a Teletext Service

A burst of errors due to ignition interference would impair the Teletext Service. In terms of the four criteria used to assess Teletext reception (Table 3), such a service would not meet criterion A (no errors received in 10 seconds for the entire data stream) and a higher field-strength might be necessary before the service met criterion B (no errors visible in each of 3 consecutive new acquisitions of one page). Bursts of errors caused by ignition interference would not be expected to affect significantly assessments of reception when applying criterion C or D.

* Attenuating the aerial does not in this instance simulate a lower field-strength since the level of ignition interference is also reduced.

Overall, ignition interference impaired the Teletext Service, even with no aerial attenuation, at six of the 44 representative sites tested, but the impairment was small. The maximum rate at which errors occurred due to ignition interference was 11 parity errors in 10 s and this is equivalent to one missing character in four pages of text.

Allowing for the fact that domestic installations are normally further from roads than the sites tested, it is not expected that ignition interference would cause a significant effect on a Teletext Service at v.h.f.

4.6. Overall results of site tests using professional apparatus and domestic apparatus

4.6.1. General

This section outlines the overall results obtained

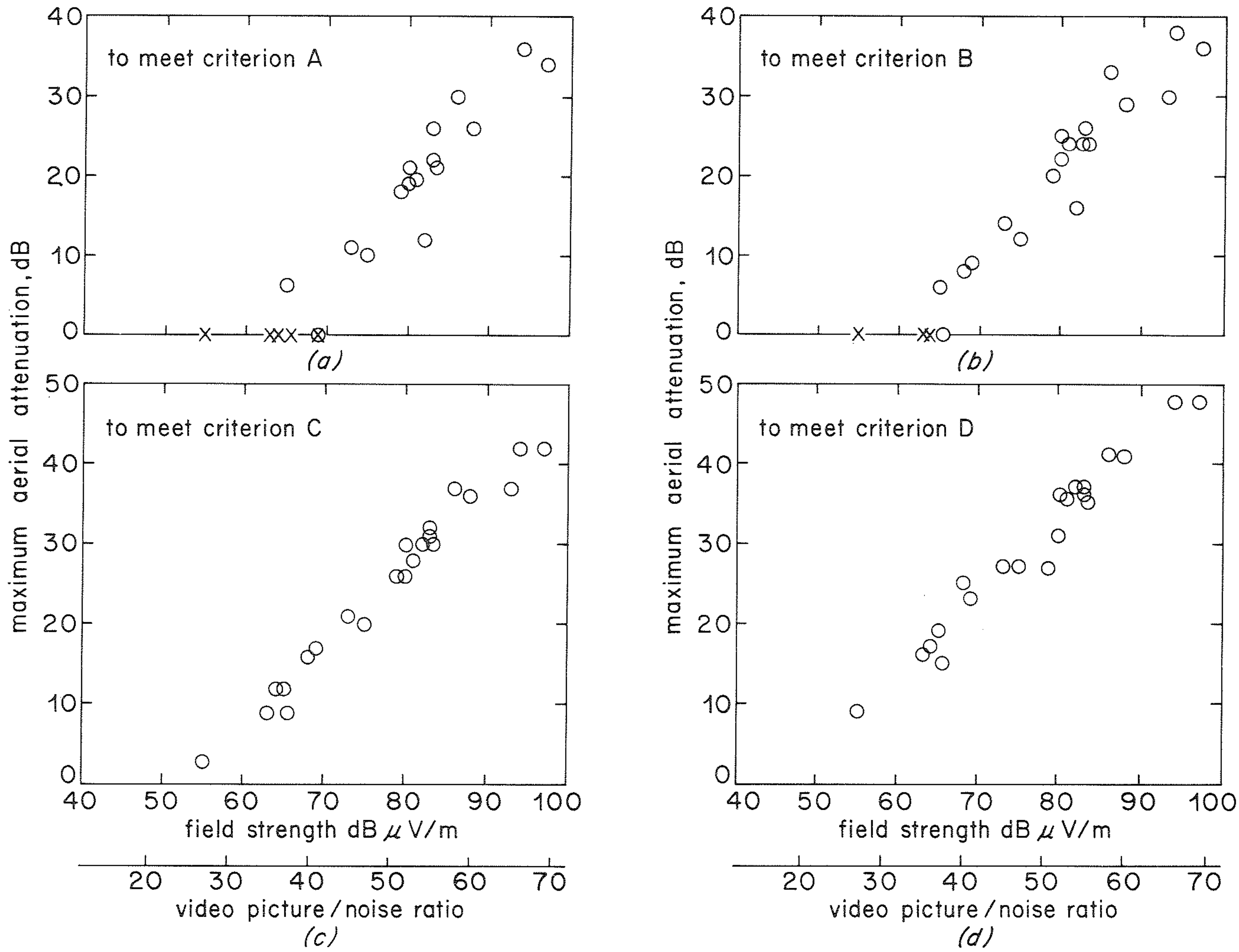
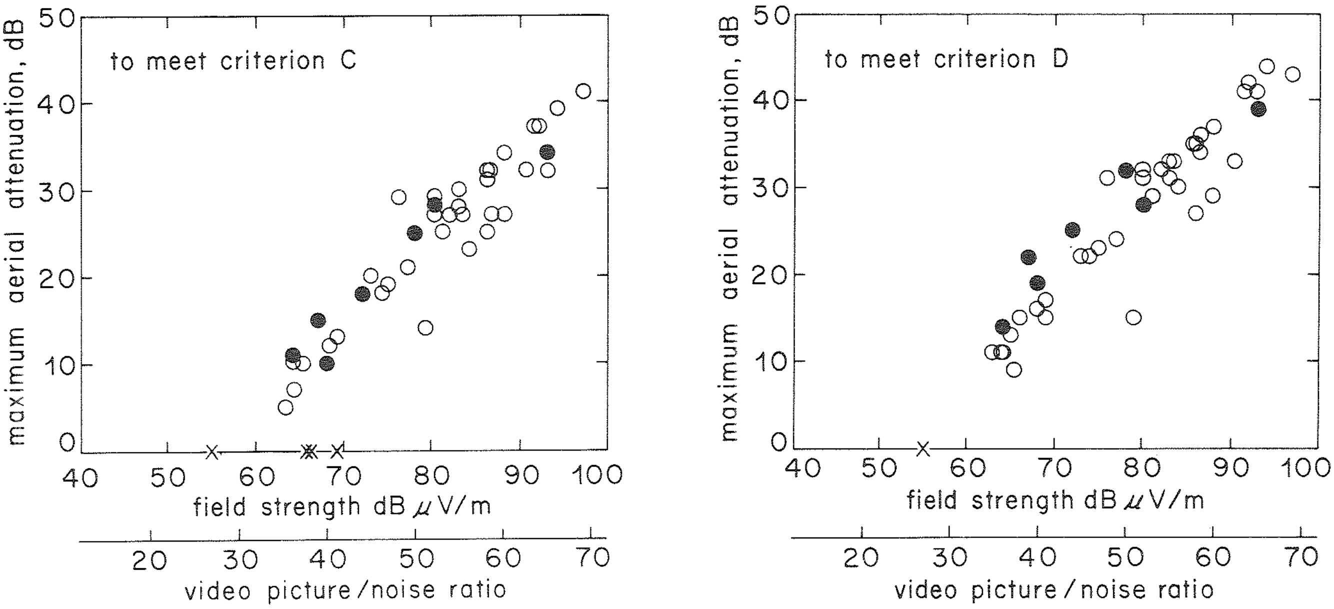


Fig. 16 - Results with professional receiver with a synchronous demodulator and a laboratory Teletext decoder

O margin where criterion was met X field strength where criterion was not met



(*a*) (*b*)

Fig. 17 - Results with domestic receiving and decoding apparatus

Commercial receiver with integral decoder
O margin to meet criterion
X field strength where criterion not met

Receiver assembly
● margin to meet criterion
▲ field strength where criterion not met

using the high-quality professional receiver (with synchronous detector) and the laboratory Teletext decoders. The overall results obtained with domestic receivers and decoders are also given; most of the results in this latter category were obtained using the domestic receiver with the integral prototype decoder.

To give some measure of the relative performance obtained at different sites, the aerial signal attenuation allowable, while still maintaining Teletext reception corresponding to a particular criterion, was plotted against the field-strength for each site. Fig. 16 shows results for all four criteria when the professional receiver and a laboratory decoder were used, and Fig. 17 shows results for criteria C and D – the only ones evaluated – when the domestic apparatus was used.

4.6.2. Using a professional receiver and decoder

Fig. 16 gives the results obtained using the professional receiver (with synchronous detector) together with one of the laboratory Teletext decoders. The results from 22 site tests are included, except that for one site measurements for criteria A and D are not available. From the total set of 25 results obtained with this apparatus, results at three sites have not been included; at one site there was an apparatus fault and, at each of the other two, there was no service from the Wendelstein transmitter (reception was normally obtained from a local transposer). At the remaining 22 sites:

for criterion A, there were five failures
for criterion B, there were three failures
for criterion C, there were no failures
for criterion D, there were no failures.

Of the failures to meet criteria A and B, one was because of low field-strength (55 dB μV/m); the remainder were caused by ignition interference or ignition interference combined with low field-strength.

It might be expected that, for a given criterion, the reception margin will be linearly related to the field-strength, and sites with a lower field-strength will on average have a margin which is lower by the same amount. Toward lower field-strength however, the margin tends to decrease faster than the field-strength, which suggests that multipath is more troublesome at such sites. Allowing for this effect it is possible to derive the mean field-strength at which each criterion would just fail to be met, i.e. the reception margin would be zero. These field-strengths with professional apparatus are:

Criterion A,	65 dB μV/m
Criterion B,	61·5 dB μV/m
Criterion C,	52·5 dB μV/m
Criterion D,	47 dB μV/m.

4.6.3. Using domestic apparatus

For the domestic apparatus, only criteria C and D were used. Fig. 17 shows 37 results which relate to the domestic receiver with integral prototype Teletext decoder, and 7 results using an assembly of one of the two sets of current System B television tuner/i.f. units in conjunction with one of the laboratory decoders. The three results referred to in 4.6.2 above have again been excluded. For the 44 results used:

for criterion C there were four failures
for criterion D there was one failure.

Of the four failures to meet criterion C one was at a site where the field-strength of only 55 dB μV/m was insufficient to give a colour television service. Of the remaining three one was in an industrial area where the direct signal was masked by a large metal tower. There was a house close to the site, however, and the result would, therefore, be representative of the reception at that one installation. The other two failures occurred in areas of fairly dense population where the signal was affected by large local obstructions. Failures of these kinds might be expected within the service area. In each case the received picture quality was satisfactory but close-spaced echoes caused the Teletext quality to be unsatisfactory. For these sites the data eye-heights at the output of the professional receiver (with synchronous detector) were about 30%. Eye-heights could not be recorded for the domestic receiver with integral decoder but, at the site where satisfactory Teletext reception was not possible, the eye-height at the output of the commercial System B tuner/i.f. unit was less than 20%.

As for the professional-receiver results, the domestic results also suggested some tendency for the margin at low field-strength sites to be less than that corresponding to the reduction in field-strength. The mean field-strengths at which each criterion would just fail to be met (i.e. the margin would be zero) using domestic apparatus are:

Criterion C 56·5 dB μV/m
Criterion D 51 dB μV/m.

It will be seen that these figures are about 4 dB higher than those obtained using the professional apparatus.

4.6.4. Comparison between the observed Teletext Service and the colour television service

Fig. 18 summarises the Teletext performance for all sites using both professional apparatus and the commercial receiver with integral Teletext decoder. A curve is also included to allow the average Teletext performance for any criterion to be related to the mean colour television picture Grade on the basis that the picture is impaired by noise alone.

The aerial attenuation used to produce a particular criterion of Teletext performance (the field-strength margin for that criterion), has been subtracted from the actual field-strength for the site to give this simulated field-strength for the criterion to be just met. Results for the two unserved sites and the site where there was an apparatus fault have not been included.

For sites where a criterion was not met (implying a negative margin of unknown magnitude) the field-strength has been indicated separately.

From Fig. 18 the Teletext performance with domestic reception equipment would, in most cases, meet criterion C at sites where the field-strength was so low as to cause a noisy television picture, of grade 2 (Poor), i.e. just outside the television service area.

The effects of using professional, rather than domestic reception equipment can be seen from the results shown for Criterion C and D. On average the professional apparatus gave the same performance with some 4 dB less field-strength.

With professional apparatus, the Teletext performance at sites deemed to be served with a fair (grade 3) television picture would, in most cases, meet Criterion B, i.e. there would be no visible errors in each of three consecutive acquisitions of a page.

Although, as explained earlier in Section 2.3 of this report, it is difficult to assign a subjective grade to an impaired Teletext performance which just meets a particular criterion, the results presented in Fig. 18 indicate a Teletext performance at least as good as the television picture when the signal has a low field-strength. Moreover, because the results quoted for Teletext include the effects of other impairments such as impulsive interference and multipath propagation, whereas the grades quoted for the television picture relate only to noise, there is probably a further margin in favour of Teletext at the edge of the television service area.

TABLE 6

Results of 'Domestic' Tests

Site	Picture grade (no attenuation)	Margin for no Teletext errors remaining after two writes (criterion C) dB	Picture grade with r.f. signal attenuated to give 50% Teletext on one acquisition (criterion D)
D1	4	33	2
D2	4	30	1½
D3	3½	22	1½
D4	4	34	2
D5	4	25	1½
D6	4	31	1½
D7	4	33	1½
D8	4	37	1½

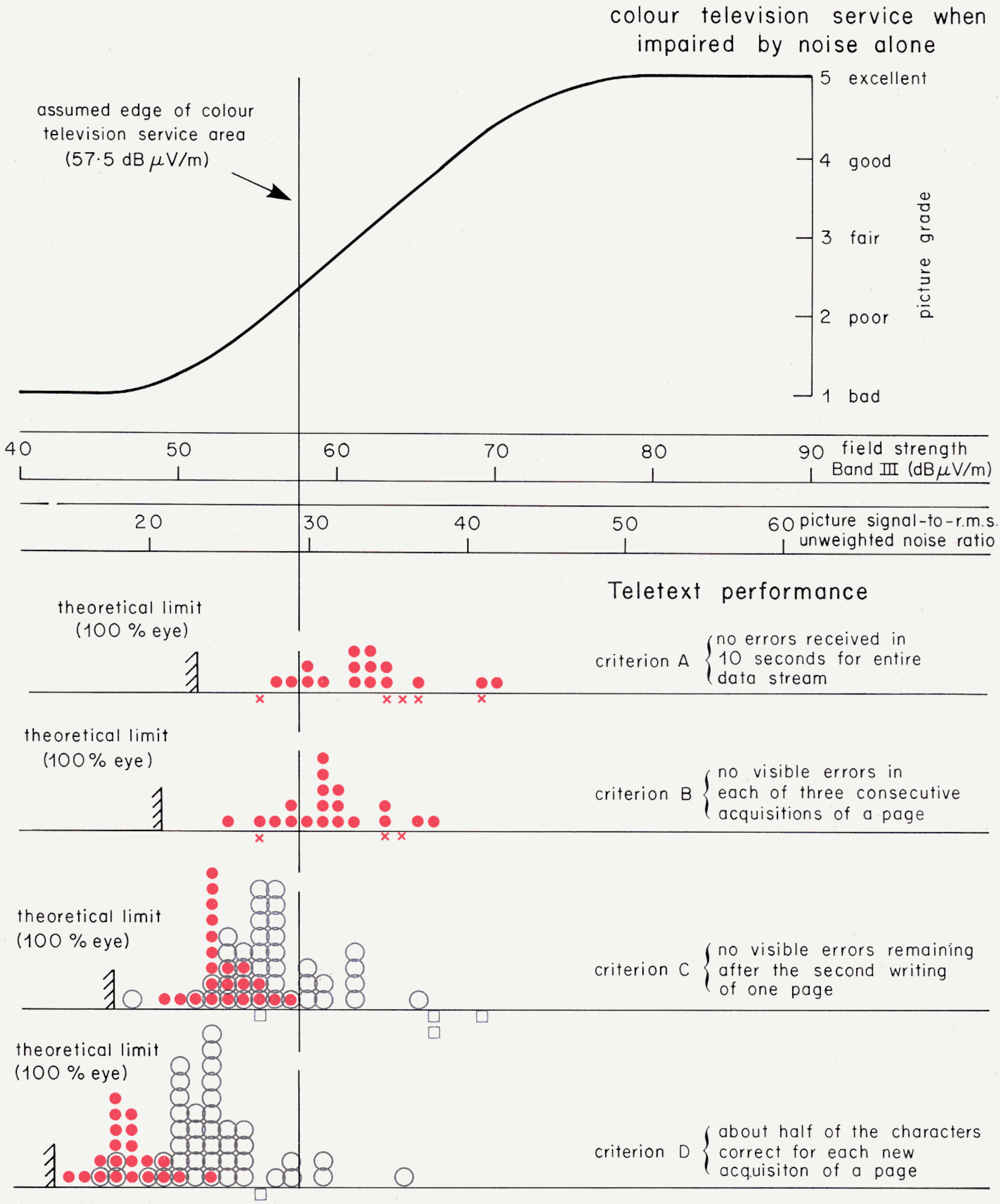


Fig. 18 - Comparison between television performance and Teletext performance at limiting field strengths

● Simulated field strengths, professional apparatus, criterion just met

× Field strength where professional apparatus failed to meet criterion

○ Simulated field strengths, domestic apparatus, criterion just met

□ Field strength where domestic apparatus failed to meet criterion

4.6.5. Tests using domestic aerial installations

The results obtained during the 'Domestic' Tests described in Section 3.4 (c) are given in Table 6.

The attenuation margins quoted for satisfactory Teletext reception are based on no errors remaining after two acquisitions of one page. It was not possible to carry out signal-strength or signal-to-noise ratio measurements in the course of these tests. However the picture-grade was assessed when the signal from the aerial had been attenuated to give 50% Teletext on each acquisition.

These tests have shown that, using the domestic receiver with integral prototype decoder, no problems were experienced with domestic aerial and distribution installations. Margins for Teletext reception, as compared with television reception, similar to those measured in the field-trials, using mobile test apparatus, can be expected.

4.7. Summary of test results

4.7.1. The Wendelstein transmitter and its input-signal chain

The Wendelstein transmitter and its input-signal chain were found to give a good quality Teletext signal. The signal received at a 'clean' site was found to have a 68% eye-height compared with an eye-height of 71% using the same receiver and a test modulator. The main impairment of the transmitted signal was a small echo, estimated to be about 7% and delayed by 500 ns, which was observed at all sites.

4.7.2. The effects of multipath propagation

Results using a professional receiver and decoder showed that, for the sites tested, the average effect of multipath propagation would require the field-strength necessary for a criterion B Teletext service to be greater than 58 dB μV/m and to be greater than 52 dB μV/m for criterion C.

4.7.3. The effects of ignition interference

In the worst case the errors caused by ignition interference occurred in bursts of up to 20 errors, but only two or three percent of pages selected were affected. Thus only the assessments of Teletext service based on the most stringent criterion were affected.

In total, there were 13 instances out of 44 sites tested where ignition interference affected the Teletext Service, and of these seven did not show the effects until the aerial input signal was attenuated. The occurrence of ignition interference would be expected to be particularly high because most test sites were adjacent to roads and some were in areas of heavy traffic. For typical domestic installations, ignition interference would not be expected to cause any significant impairment of the Teletext service.

4.7.4. Tests using domestic aerial installations

These were conducted at eight domestic installations using a domestic receiver with integral prototype Teletext decoder. Each of the installations involved a communal aerial system and there were no problems with Teletext reception.

4.7.5. Overall results

The professional receiver with laboratory decoder met criteria C and D at 23 out of the 25 sites at which the arrangement was used. The two failures were at sites which were not served by the Wendelstein transmitter. At one of the successful sites the Teletext reception met all criteria despite an apparatus fault. For criterion B there were an additional three failures compared with criteria C and D and criterion A produced a further two failures.

Forty seven sites were tested using domestic apparatus, of which two were not served by the Wendelstein transmitter (as above) and for one the field-strength was below the limit for colour television reception. For the remaining 44 sites there was one failure to meet criterion D and a further three failures to meet criterion C. It should be noted that the professional equipment met criteria C and D at the sites where the domestic equipment failed. Criteria A and B were not tested with the domestic apparatus.

Table 7 summarises the number of successful sites for each criterion with both professional and domestic apparatus.

TABLE 7

Summary of Sites Which Met Criteria and Total Number of Sites Considered

Criterion	Professional				Domestic			
	A	B	C	D	A	B	C	D
Total number of sites tested	25	25	25	25	–	–	47	47
Sites excluded as unserved	2	2	2	2	–	–	2	2
Sites excluded for low field strength	–	–	–	–	–	–	1	1
No. of sites after exclusions	23	23	23	23	–	–	44	44
Sites which met criterion	18	20	23	23	–	–	40	43

TABLE 8

		Affects S/N ratio	Affects pulse distortion
Factors in the transmitting network and in receiving and decoding equipment which can alter the Teletext performance from that found in the field tests.			
Different Teletext sources	effect of other data levels	X	
	effect of other source filters		X
Different transmitting arrangements	effect of other studio to transmitter links		X
	effect of different transmitter performance		X
	effect of including re-broadcast links in the transmission chain	X	X see text
	effect of including transposers in the transmission chain	X	X
Different propagation conditions	effect of mountains, valleys, traffic, weather, co-channel interference		X
Different v.h.f. video receiving equipment	effect of different receiving aerial	X	X
	effect of receiver with a lower or higher noise figure	X	
	effect of different receiver i.f. amplitude response		X
	effect of different receiver i.f. group delay response		X
	effect of a quasi synchronous or envelope detector		X
Different Teletext decoders	effect of various types of data slice circuitry	see text	
	effect of various methods of data clock regeneration	see text	

5. Effect of arrangements other than those tested

5.1. General

As explained in Section 2.1 it was possible to test only a very small proportion of all the possible network and receiving arrangements in the two weeks available for the tests in Germany. Thus the measurements were made in such a way that it would be easier to assess the likely effect of alternative situations. This led to the use of professional rather than commercial v.h.f. receiving equipment and laboratory error-counting Teletext decoders rather than domestic equipment.

5.2. Causes of possible differences

It is now necessary to consider how the Teletext performance might be altered when the transmitting arrangements and Teletext receiving and decoding equipment are replaced by others.

The effects which need to be considered are listed in Table 8, with each effect split up into its possible constituent causes. Most of the effects listed in the table will vary the amount of distortion of the data pulses, and the cumulative pulse distortion for the whole transmitting and receiving chain will determine the data eye-height at the decoder. Some of the effects will change the noise level. The amount of noise which can be tolerated without significant errors depends upon the data eye-height and the performance of the receiver data-recovery circuit.

The likely change in Teletext performance with each effect will now be discussed.

5.2.1. Data level

The data level used in the tests was 70% of the picture-signal level. If the transmitted data level were reduced the effect of added noise would be increased and the overall reduction in the data signal-to-noise ratio, in dB, would be numerically equal to the data-level reduction in dB. It follows that the field-strength at which the service failed would increase by the same amount. The converse would apply if the data level were increased, but this would increase the possibility of interference with sound. An increased data level could also increase the amount of quadrature distortion in the receiver demodulator (see Section 5.2.10).

5.2.2. Source filter

The source-filtering used in the tests comprised a filter to produce raised-cosine pulses from rectangular data pulses followed by a sharp-cut low-pass filter with a response 3 dB down at 4·6 MHz. It is possible that the transmitted

data eye-height could be increased by the use of a different filter characteristic, and this would mean that the service area for Teletext would be increased.

5.2.3. Studio-to-transmitter links

Studio-to-transmitter links usually add very little pulse distortion and, in data terms, insignificant noise to the signal, especially when compared with the effects likely to occur elsewhere in the chain. It is therefore extremely unlikely that they will affect the overall system performance.

5.2.4. Transmitter

The transmitter used for the field tests was optimised about one week before the trials, using a 1T pulse. No deterioration was detected in the standard of performance during the test period. Where the response/frequency and group-delay/frequency characteristics are not ideal, the defects cause distortions of the data pulses which, together with all other sources of pulse distortion, reduce the received data eye-height. The Wendelstein transmitter, when received at a clean site using a professional receiver, gave an eye-height of 68% as compared with an eye-height of 71% obtained when the same receiver was fed with a test modulator. A poor transmitter alignment might reduce the eye-height and decrease the Teletext service area.

5.2.5. Rebroadcast links

When a rebroadcast link (RBL) is included in the transmission chain the pulse distortions and noise due to the first transmitter, the propagation path and the rebroadcast receiver will compound with those produced by the second transmitter. This creates a situation where the service area of the second transmitter will usually be less than if it were fed by land line or s.h.f. link.

Provided that the input to a transmitter is in baseband video form, a data regenerator can be used to remove completely any distortions in the incoming data-signal. Any RBL-fed transmitter could have a data regenerator at its input, and in such circumstances the quality of its Teletext output could be at least as good as any line-or s.h.f.-link fed transmitter.

5.2.6. Transposers

A transposer is a transmitter, usually of low power, fed by an 'off-air' receiving system in which the r.f. signal is not demodulated. Unlike an RBL transmitter, a transposer cannot easily employ a data regenerator. Fortunately, however, the distortions caused by transposers are usually less severe because of the absence of the demodulation and remodulation processes. If, therefore, any transposer in a chain were to receive a signal containing distortions due to multipath propagation, it would retransmit them and the signal from subsequent transposers would be degraded.

An analysis of the output signals of some 84 transposers in Germany, based upon information supplied by the IRT, suggests that, for eight of these, there could be difficulties in providing a satisfactory Teletext service.

5.2.7. Topography of service area

The service area of the Wendelstein transmitter includes a wide range of topographical features. Caution should be exercised in applying these results to other service areas, even though the range of topographical features might be similar.

Considerable attention was given to investigating interference from traffic, and changes between one service area and another are not expected. Although changes of weather e.g. rain, could affect multipath propagation, a range of weather conditions occurred during the tests and no overall degradation of service was observed. Currently tolerable amounts of co-channel interference need not cause a problem for Teletext receivers, providing the decoder data-recovery circuits are designed to allow for it.

5.2.8. Receiving aerial

As discussed in Section 3.3.2 the characteristics of the receiving aerial installation (including feeder etc.) used in the field tests were close to the minimum values specified for use in Germany. Considerable advantage could often be gained by using a more directive and higher-gain aerial. This would both reduce the effects of multipath distortions arising from objects close to the receiver and provide a larger signal so that there would be less noise on the demodulated video signal. It should be possible to receive Teletext successfully with a minimum field-strength lower than the values found in the field trials by using an aerial of the type seen in use at many domestic installations at the edge of the service area. These were normally 12-element aerials compared with the five-element aerial used in the tests. A better aerial would, of course, also improve the picture quality.

5.2.9. Receiver noise figure

The field-trial aerial-distribution system was arranged to simulate a domestic receiving system with a noise figure of 7 dB. A Band III receiver with a noise figure of only 4 dB is available. Such a receiver would make it possible to reduce the minimum field-strength for Teletext reception by 3 dB.

5.2.10. Reciever i.f. and detector

A professional receiver was used for most of the field trials. This had good i.f. response/frequency and group-delay/frequency characteristics and employed a synchronous detector which did not produce any measurable quadrature distortion. By contrast a typical domestic receiver will have i.f. characteristics which cause a greater distortion of the data pulses than in the case of the professional receiver, and a detector with a less satisfactory characteristic.

Recent developments of surface-acoustic-wave filter technology are enabling good i.f. responses to be achieved

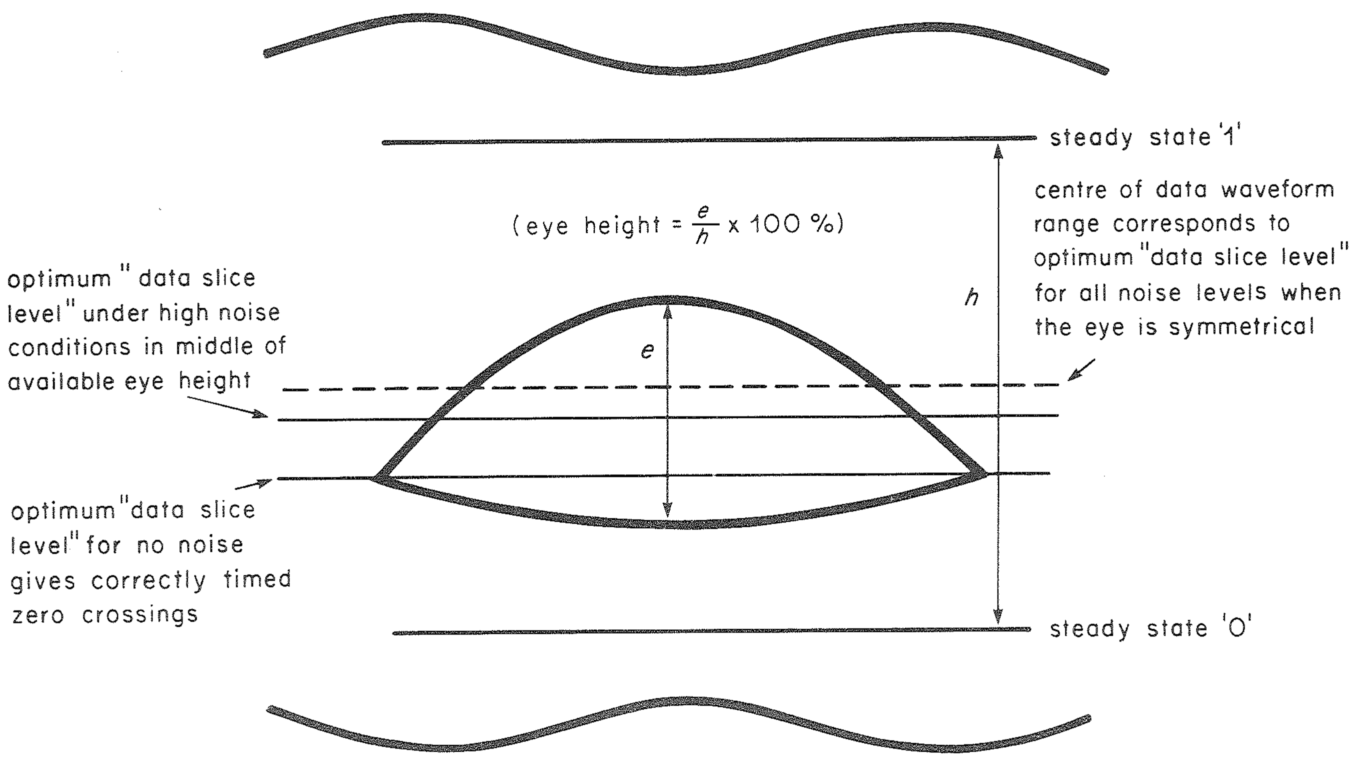


Fig. 19 - An asymmetric data eye pattern showing how the optimum slicing level differs between no noise and high noise conditions

reliably. If this technology is developed and found suitable for commercial domestic applications the Teletext performance of domestic receiving apparatus might be limited mainly by the vision detector.

Receivers fitted with envelope detectors give rise to an asymmetric eye because quadrature distortion is introduced. An asymmetric eye, such as that shown in exaggerated form in Fig. 19, will require compromises to be made in the data decoding circuit.

Increasingly, commercial receivers are being fitted with 'enhanced-carrier' or 'quasi-synchronous' detectors. These exhibit less quadrature distortion than envelope detectors and give rise to eyes which are more symmetrical.

The commercial System B receiver with integral Teletext decoder was fitted with an enhanced-carrier detector and gave an eye-height, when connected to a test source, of 70%. This performance is expected to be equalled by other commercial receivers.

5.2.11. Teletext decoder

In the decoders used in the tests the data recovery was dependent on data-slicing and clock-regenerating circuits.

The laboratory decoders used in the tests had manually adjustable data-slice reference-voltages and could work down to about 10% eye-height, whereas some of the commercial prototype decoders had adaptive data-slice levels which maintain the data-slice level midway between the peaks of the data waveform. With an adaptive data-slice circuit, the slice voltage is perturbed, to some extent, by the data, thus using up some of the eye-height available to the decoder. Hence the error rate for a particular signal-to-noise ratio is increased in a decoder with an adaptive data-slice circuit; the effect being greater when the eye-height of the Teletext signal is small.

This fact, that the difference between Teletext decoders becomes more marked for lower received eye-heights, is readily apparent from the calibration results shown in Appendix 6, Figs. A6.1, A6.2 and A6.3. The spread between various decoders at very-high error rates is explained by differences in the clock-regeneration circuits, i.e. in some decoders the clock regenerator is less affected by high levels of noise.

Taking all three cases shown, the largest differences in performance occur in Fig. A6.3. Here, at an error rate equivalent to no errors remaining after two writes, the difference between the average for the laboratory decoders and the average for the commercial decoders is 3 dB. This applies for an eye-height of 44%, which was the average measured for all sites using the professional receiver.

5.3. Summary of predictions of effects of arrangements other than those tested

Within the service areas of main transmitters operating on television System B, results similar to those given for the commercial receiver with integral Teletext decoder might be expected. Where the transmitter is of poor performance there might be some reduction of the Teletext service area.

In areas of severe multipath distortion it might be necessary to install a more directional aerial, perhaps on a taller mast. This might also improve the picture.

Where a transposer receives a signal under multipath conditions the Teletext service area of that transposer might be considerably smaller than its colour television service area.

6. Conclusions

In April 1975, field tests were conducted within the service area of the Wendelstein v.h.f. transmitter in Bavaria. The tests were made mainly by using a professional v.h.f. System B receiver and a laboratory-type Teletext decoder. The performance of a commercial receiver fitted with an early experimental Teletext decoder was assessed at most of the test sites and other tests were made to explore differences that might be expected when using other domestic-type equipment in place of the professional equipment.

The trials have shown that there is no close correspondence between television picture quality and the quality of Teletext data reception. Thus a good television performance does not ensure a good Teletext performance, but Teletext can function perfectly even when the television picture is unacceptably noisy.

When television and Teletext reception were compared there was, on average, a margin of field-strength in favour of Teletext.

Of the 44 sites served by television, at which the domestic equipment was used, a Teletext service was available at 40 (91%).

The Teletext performance observed during the tests in Bavaria was limited by the apparatus then available. The domestic aerials observed in the area were generally better sited and sometimes of higher gain than that on the survey vehicle, although the installation might be more prone to reflections. The domestic-receiver performance could be improved upon by attention to the tuner noise-factor, the i.f. characteristics and the detector linearity, while the decoder data-acquisition circuits are also capable of improvements.

Overall it has been shown that a good Teletext service can be provided where the television transmission standard is v.h.f. System B and the Teletext parameters are as recommended for use in the U.K. with u.h.f. television transmission System I.

7. Acknowledgements

The work reported here was conducted jointly by the BBC and the IBA, who are indebted to the Director of Research of the IRT for making these tests possible and to the engineers of the IRT for their considerable help and co-operation in conducting the tests.

8. References

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   Now superseded by:
   BBC, IBA, BREMA. 1976. (September). Broadcast Teletext specification. ISBN 0 563 17261 4.

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3. Documents of CCIR XIIIth Plenary Assembly, Geneva. 1974, Vol. XI, Broadcasting Service (Television) (Study Group 11).

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Appendix 1

BBC Test Pages

1. General

The Test Pages generator is a transportable source of Teletext. It requires a feed of mixed synchronising pulses and delivers a Teletext coded data signal on two adjacent television lines for addition to a video signal in the field blanking interval.

2. Page details

The pages are numbered 1 to 60.

The first displayed character pairs in each line are 'SM' and were selected as providing a particularly testing data sequence (11001011, 10110011) bearing in mind the bit-rate and bandwidth limitations of the system.

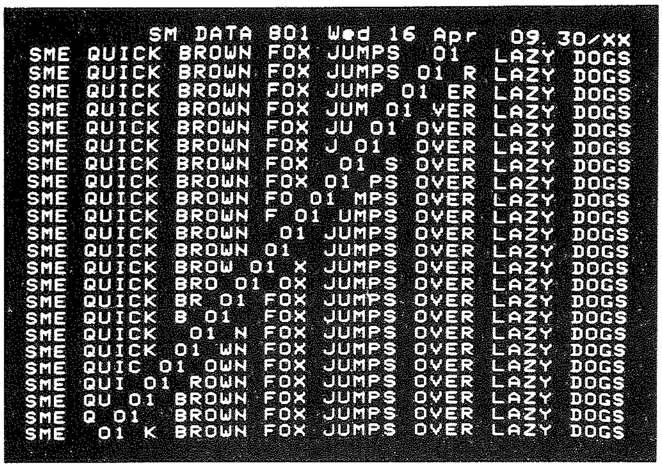


Fig. A1.1 - Test pages numbered 1, 4, 7, 10 and so on, except page 19 — Example shows page 1

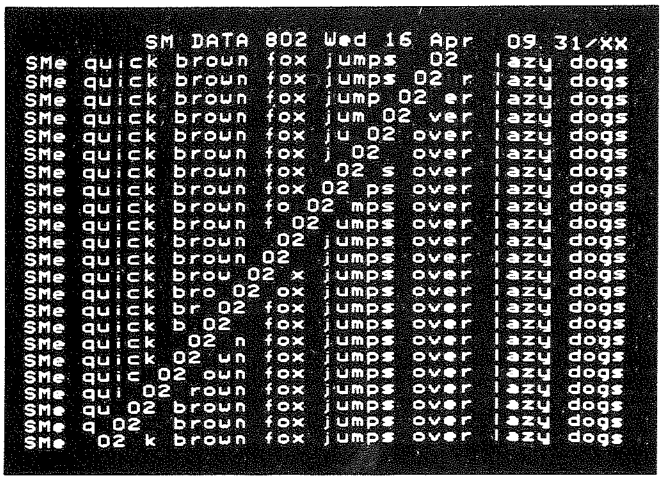


Fig. A1.2 - Test pages numbered 2, 5, 8, 11 and so on, except page 59 — Example shows page 2

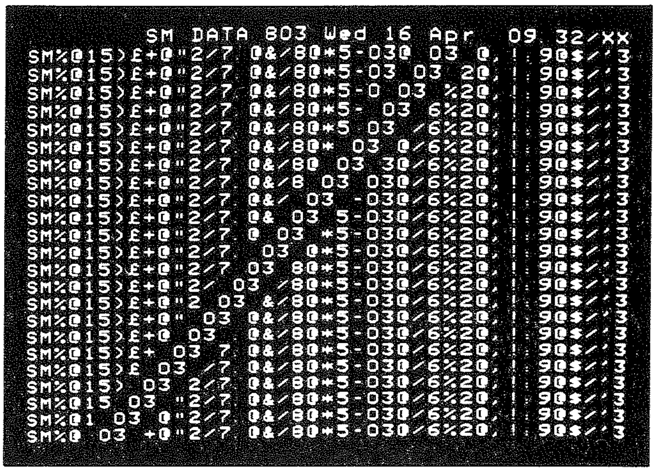


Fig. A1.3 - Test pages numbered 3, 6, 9, 12 and so on, except page 39 — Example shows page 3

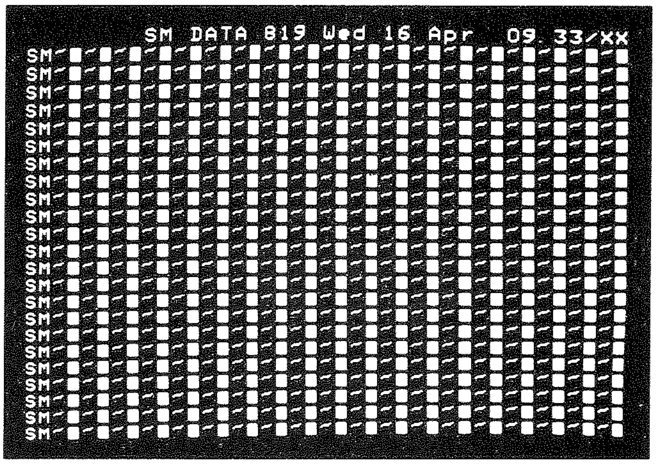


Fig. A1.4 - Test pages numbered 19, 39, 59. 'clock-cracker' pages giving minimum synchronising information — Example shows page 19

Four different pages are generated as shown in Figs. A1.1 to A1.4. Pages 19, 39 and 59 are special 'clock-cracker' pages where the character pairs 'DELETE', 'BAR' give a data sequence (11111110, 01111111) which gives the minimum of data timing information and is therefore especially testing for the bit synchronous clock regeneration processes in Teletext decoders.

Each page, except the 'clock-cracker' page, carries a diagonal stripe which contains the page number and aids identification of errors in page and row addresses.

Every page header carries the true date information, as shown in the photographs, together with the clock time hours and minutes (with seconds unchanging and shown 'XX').

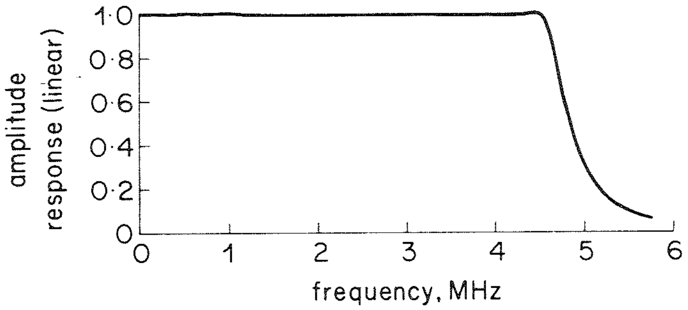


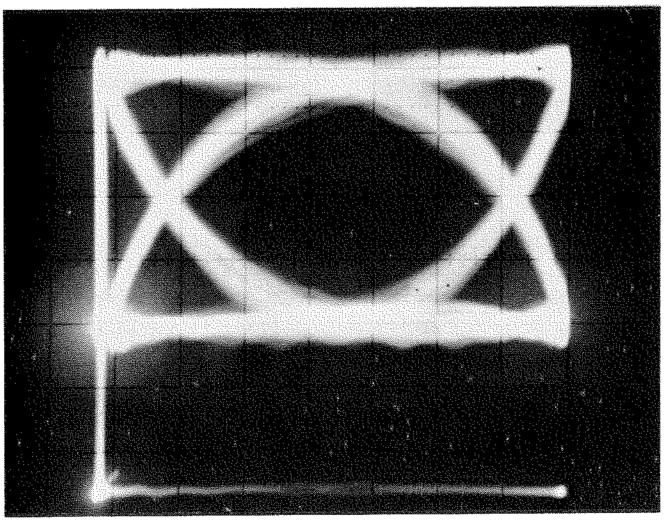
Fig. A 1.5 - Amplitude response of truncating filter

All control bits are set to zero and no control characters are included in the texts.

3. Output pulse shape

The data signal at the output of the generator is of the form: raised cosine pulses with a spectrum truncated by a low pass filter whose amplitude/frequency characteristic is shown in Fig. A1.5.

The eye-pattern for the data is shown in Fig. A1.6.



Eye-height = 78%
Peak-to-peak data amplitude = 116%

Fig. A1.6 - Eye display of Teletext waveform at output of Test pages source

The eye-height is 78% and the peak-to-peak data amplitude is 116%.

Appendix 2

Relationships Between Field Strength, Signal Level, and Signal-to-Noise Ratios

1. Field strength from measured signal level

Theoretically the field strength can be derived from the receiver input voltage by the following equation:

$$E(\mathrm{dB}) = U_i(\mathrm{dB}) + 20 \,.\, \log[6{,}94/\lambda] + c - g\lambda/2$$

Where E = Field strength in dB related to 1μV/m
U_i = Receiver input voltage in dB related to 1μV
λ = Received wavelength in metres = 1·42 m
c = Cable loss = 1·5 dB at 210·25 MHz
$g\lambda/2$ = Aerial gain relative to a half wave dipole = 7 dB.

The numerical values indicated are as for the configuration used. In this way we get:

$$E(\mathrm{dB}) = U_i(\mathrm{dB}) + 6{\cdot}78 \text{ dB} + 1{\cdot}5 \text{ dB}$$

The receiver input voltage U_i was measured with the Plisch receiver. Comparison measurements with the Rohde und Schwarz receiver indicated, that the input voltage measured with the Plisch receiver is 1·5 dB too high.

Consequently the field strength E can be derived from the indicated input voltage U_i' of the Plisch receiver by the formula.

$$E(\mathrm{dB}) = U_i'(\mathrm{dB}) + 6{\cdot}78 \text{ dB}$$

2. Field strength and signal-to-noise ratio for a typical domestic installation

For the domestic aerial installation as shown in Fig. 5 in the main body of the report.

Aerial gain = 6·5 dB (reference half-wave dipole)
Losses = 5·3 dB
Noise factor = 7 dB

Therefore nett aerial gain = 1·2 dB.

Using the same theory as 1 above:

Field strength (dB μV/m) = signal voltage (dB μV) + 12·58 dB

Signal voltage was measured as r.m.s. value of carrier during peak syncs.

Therefore detected picture signal level
= measured signal voltage
+3 dB (r.m.s. – peak)
–6 dB (relative attenuation of carrier prior to detection)
–5 dB (picture signal relative to peak carrier)
= measured signal voltage –8 dB

Also 7 dB noise factor is equivalent to an effective noise voltage across 60Ω of 7·8 dB w.r.t. 1μV.

Hence, unweighted signal-to-noise ratio = measured signal voltage – 15·8 dB
unweighted signal-to-noise ratio = Field strength –28·38 dB

Weighting makes approximately 8 dB difference.

So, weighted S/N ratio = Field strength – 20·38 dB.

Note: In the field tests the signal level and unweighted signal-to-noise ratio were measured. The average result was:

Unweighted signal-to-noise ratio = Field strength –28·26 dB

This shows good agreement between the practical and theoretical relationships.

Appendix 3

Calibration Performance of Rohde und Schwarz Synchronous Receiver

This was calibrated in conjunction with a test modulator also provided by Rohde und Schwarz.

The Teletext eye was measured using the BBC Test Pages Teletext source and eye display unit.

Teletext eye-height 71%
Peak-to-peak data amplitude 115%

Measurements of 2T response gave:

2T response: 2T height = 103%
K_{2T} = 0·75%

The 1T pulse waveforms at the output of the receiver were photographed and analysed, using the computer technique described elsewhere.* The computed amplitude and phase responses are shown in Fig. A3.1. The computed impulse response and Teletext eye patterns are also given on that figure. The computed eye-height was 65% and computed peak-to-peak data amplitude 115%.

In the course of the tests, the centre frequency of the phase-locked oscillator used for demodulation drifted considerably with temperature and required adjustment. When the oscillator was not at the correct centre frequency, quadrature distortion was present in the demodulated output; this might have affected results at some sites.

* CEEFAX: computer based time-domain and frequency-domain analysis of system responses to test pulses. BBC Research Department Report No. 1976/18.

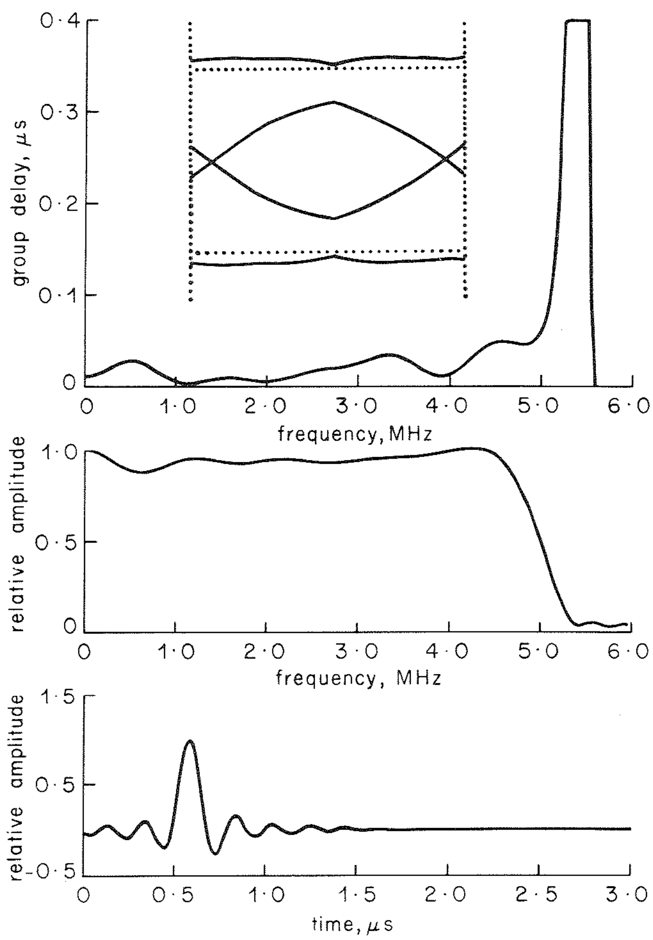


Fig. A3.1 - Computed response of Rohde und Schwarz synchronous receiver

Appendix 4

Calibration Performance of Commercial System B Receiver with Manufacturers Prototype Integral Teletext Decoder

The receiver design was as supplied for use in System B countries and employing an enhanced carrier vision detector. Some adjustments had been made by the manufacturer to improve its Teletext performance. Further improvements to the Teletext performance, were made by including a group delay correction circuit and a single R/C amplitude corrector.

The performance of the receiver was measured using a Philips modulator — System B (Netherlands). This standard differs from the System B (Germany) television standard in the exact values of group delay pre-correction. However this difference is not thought to significantly affect the results quoted below.

Teletext: Eye-height = 70%
Peak to peak data amplitude = 140%

2T response: 2T height = 100%
K_{2T} = 4%

It was not possible to test the Teletext decoder independently as no video input terminal was provided. However, the data acquisition circuits were of a conventional design employing a manually adjusted reference voltage for slicing and simple comparative tests showed its performance to be similar to that of the laboratory decoders.

Appendix 5

Calibration Performance of Two Commercial System B Tuner Assemblies

Both assemblies were provided by manufacturers as representative of present designs of System B tuners, i.f. panels, and video demodulators. Both employed enhanced carrier vision detectors.

The performances of the two were measured using the Philips System B (Netherlands) modulator.

Assembly No. 1 was used in the tests described in Section 4.6.3 of the main report.

	Assembly No. 1	Assembly No. 2
Teletext		
Eye-height	56%	54%
Peak-to-peak data amplitude	121%	126%
2T response		
2T height	89%	85%
K_{2T}	4%	4%

Appendix 6

Calibration Performance of Teletext Decoders

Two laboratory Teletext decoders were provided by the BBC and IBA. Both employed simple circuits for data acquisition where a manually adjusted voltage was used to 'slice' the data.

Three manufacturers' prototype Teletext decoders were also provided for the tests. One of these had a manually adjusted slice-voltage similar to the laboratory decoders. The other two employed adaptive data slicing.

The test results of errors at different signal-to-noise ratios are shown in Figs. A6.1 to A6.3.

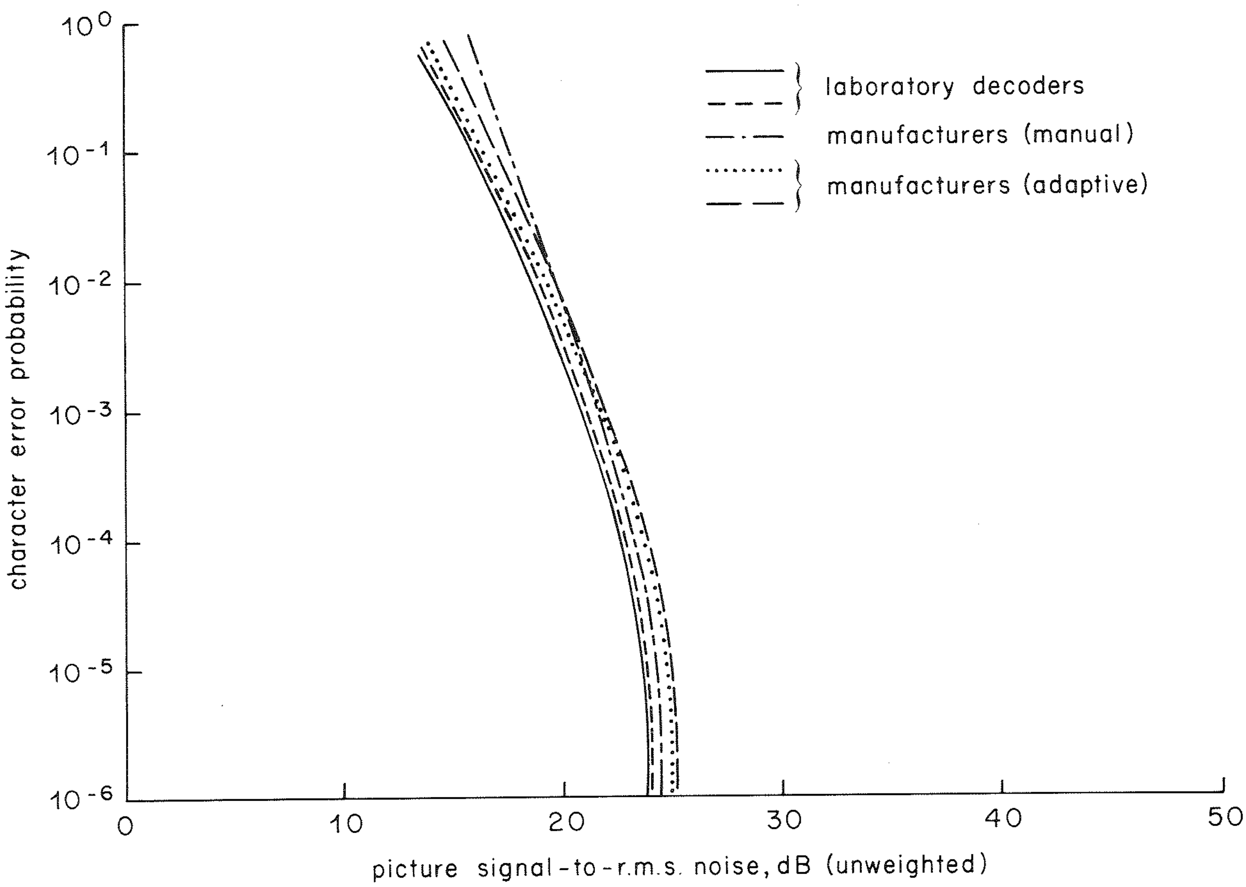


Fig. A6.1 - Performances of Teletext decoders — raised cosine data — 100% eye-height

SMW/JUC

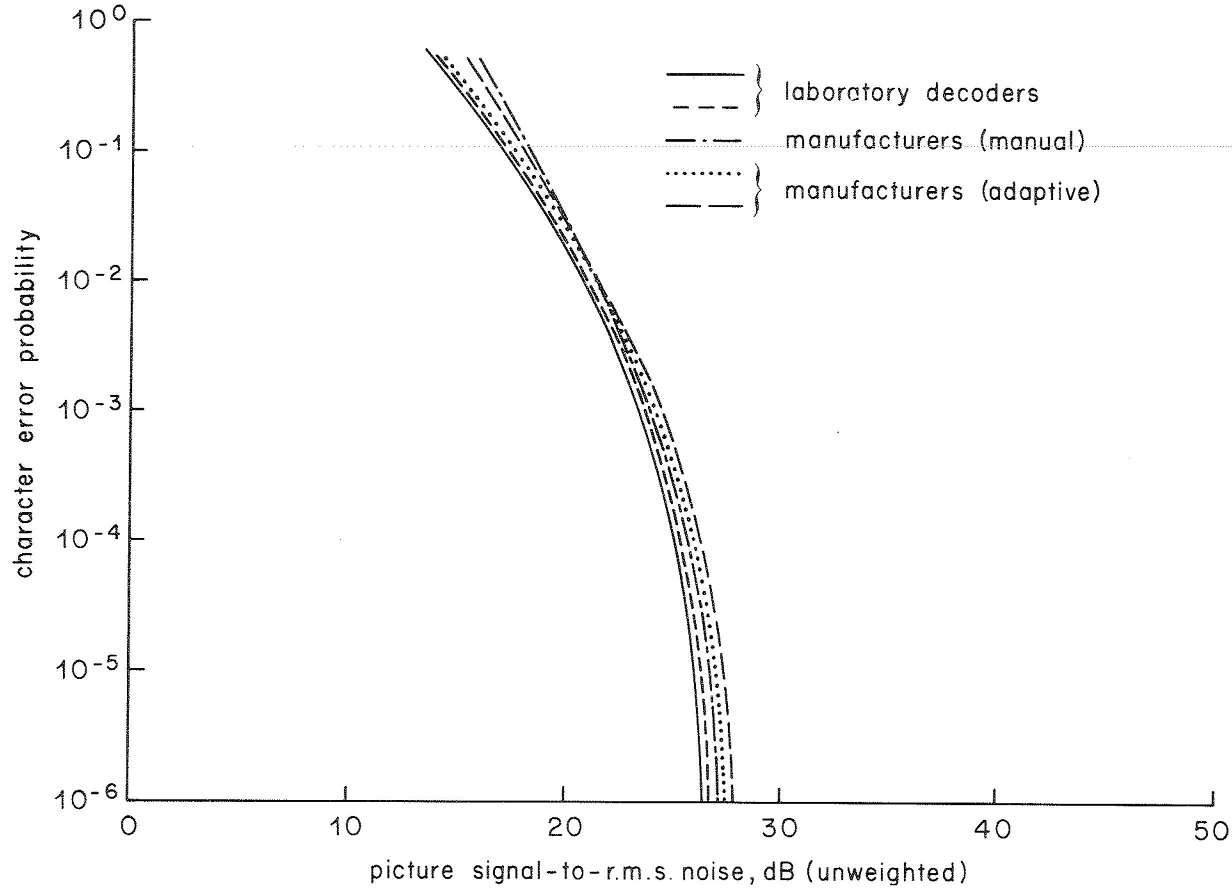


Fig. A6.2 - Performances of Teletext decoders — raised cosine data with spectrum truncated as for tests — 78% eye-height

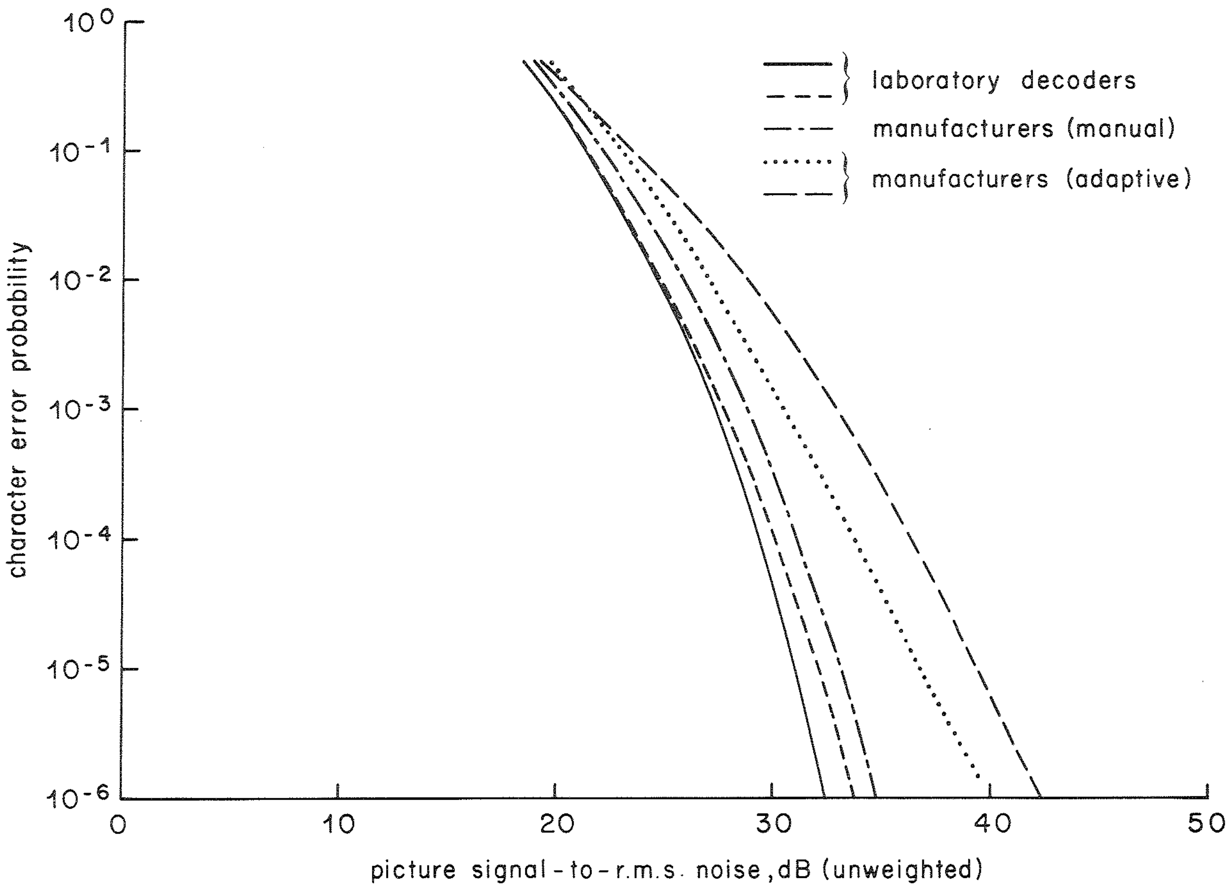


Fig. A6.3 - Performances of Teletext decoders — simulated multipath — 44% eye-height